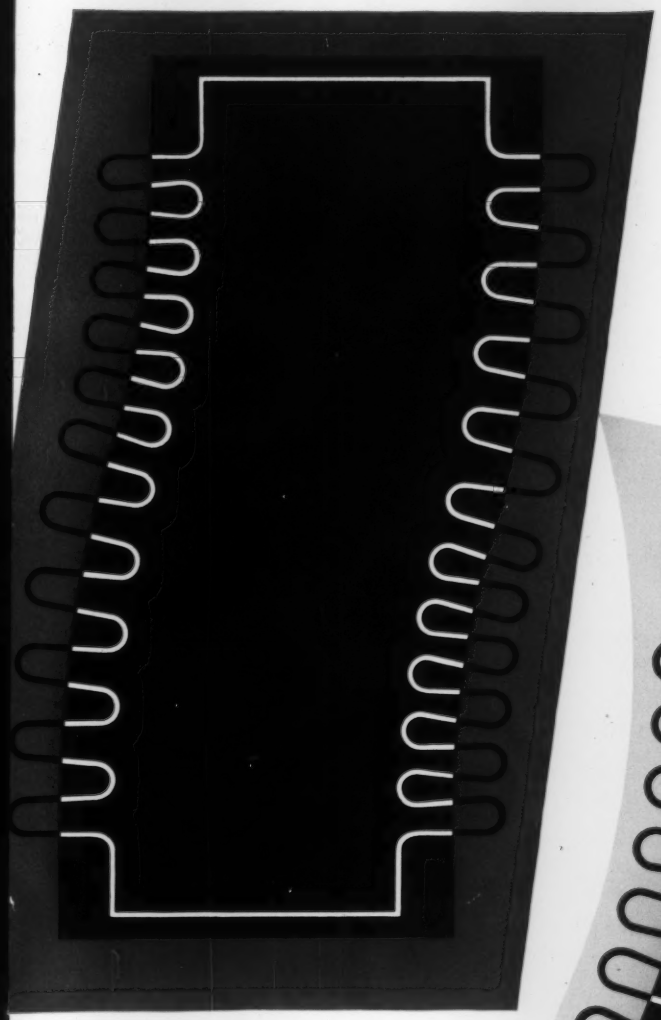
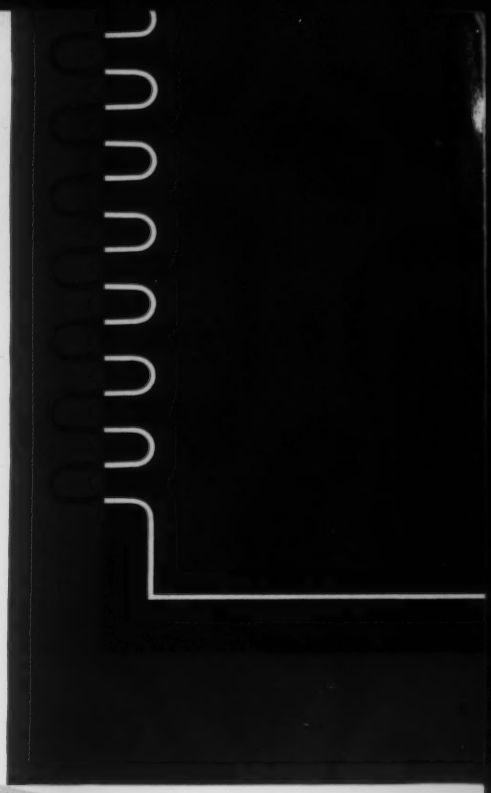
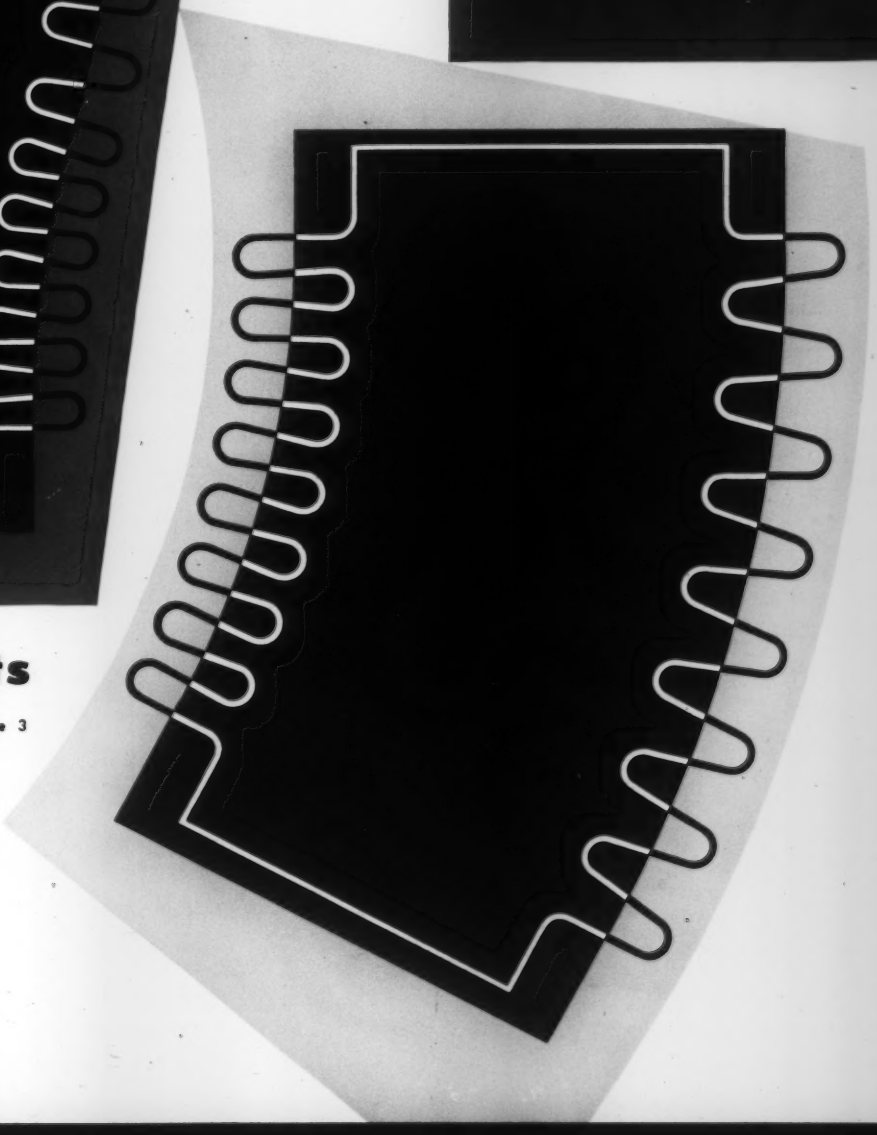
OCTOBER 15, 1959

MACHINE DESIGN

A PENTON PUBLICATION — BIWEEKLY







Bellows Joints

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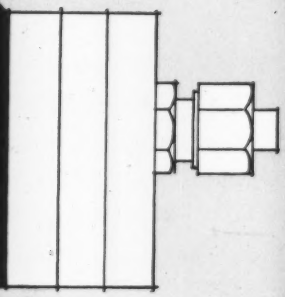
off-the-shelf pumps just right for your requirements



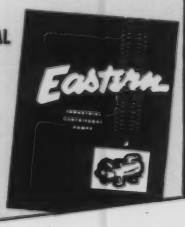
Whatever you want in a pump – for hydraulics, for flow or process control, there is likely to be an Eastern ready-made unit . . . made-to-order for your needs.

CAN YOU USE THESE PUMP FEATURES:

- ☐ corrosion resistant construction for chemical solutions?
- ☐ ability to handle organic and inorganic fluids at various temperatures with flows up to 70 GPM, pressures to 65 psig?
- ☐ available with open, enclosed or explosion proof motors?
- ☐ compact lightweight units with or without motor?
- ☐ high efficiencies in handling hydraulic oil, fuel and lubricants at high pressures?
- ☐ flow rates from 0.1 to 9.8 GPM, pressures from 0 to 1500 PSI?
- ☐ self-priming operation with non-lubricating liquids?
- ☐ high pressure outputs with small, low power units... and no contamination of fluid?
- ☐ flow rates from ½ GPM to 5½ GPM, pressures from 30 to 200 PSI?

An EASTERN CENTRIFUGAL PUMP MIGHT BE JUST RIGHT FOR YOU!

Write for Bulletin 120.



Look into EASTERN HYDRAULIC PUMPS!

Write for Bulletin 810

Get to know more about EASTERN POSITIVE DISPLACEMENT PUMPS!

Write for Bulletin 220.

These useful brochures contain full specifications on the complete line in each category, including performance data and tables. They will be sent to you at no obligation whatever. Write Department R.

EASTERN INDUSTRIES PUMP DIVISION®

EASTERN INDUSTRIES, INC.

100 SKIFF STREET, HAMDEN 14, CONN.

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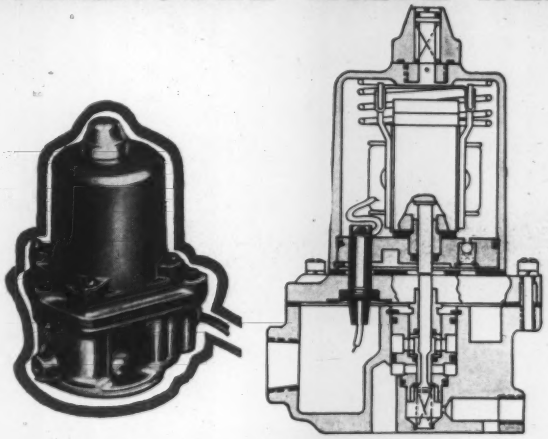
a basic Ross valve building block

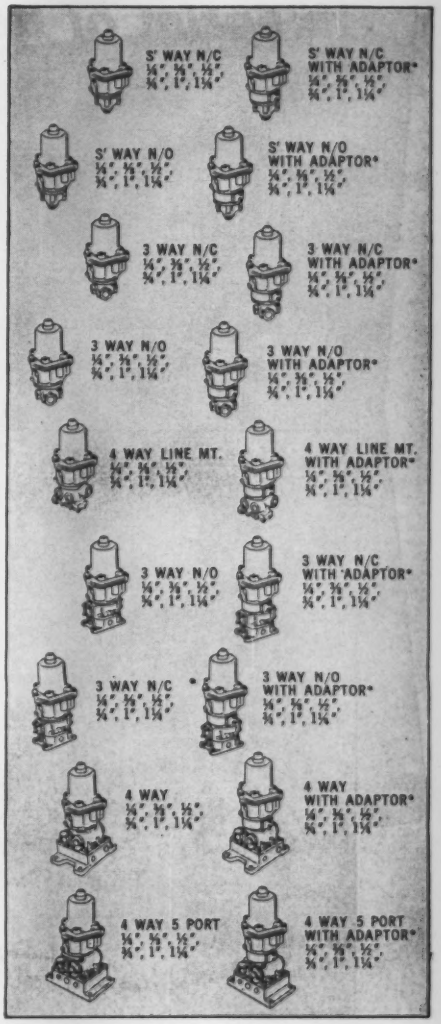
GOLDMODEL VALVE HEAD



OIL IMMERSED SOLENOID

- The finest achievement in solenoid heads
- JIC
- Over 50 million cycles in tests
- Lightning fast

Modular construction is brought to the air valve field to give you the effect of a great valve inventory without stocking a great number of valves. Stock just one of these Goldmodel heads and you have the finest solenoid actuator obtainable for any one of the 54 Skyline bodies. This is the head designed especially for those uses where dependable performance and very long life must supersede all other considerations. The dustproof solenoid is the very finest and is immersed in oil to run cool and stay young. Write for bulletin 318.


5 WAY N/C
5 WAY N/C WITH ADAPTOR*
5 WAY N/O
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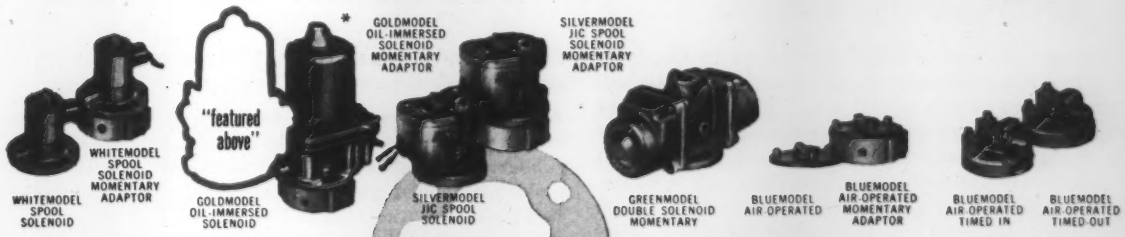

"every head meets every body at this gasket"

ALL SKYLINE HEADS AND BODIES ARE BUILDING BLOCKS TO GIVE YOU MANY VALVES FROM A FEW HEADS AND BODIES

STRAIGHTWAY NORMALLY OPEN NORMALLY CLOSED
3 WAY NORMALLY OPEN NORMALLY CLOSED
4 WAY
3 WAY NORMALLY OPEN NORMALLY CLOSED
4 WAY
4 WAY 5 PORT

STAY AHEAD MODERNIZE

ROSS OPERATING VALVE COMPANY

109 EAST GOLDEN GATE AVE. • DETROIT 3, MICH.

Circle 404 on Page 19

Blueprint of better design—

Photo courtesy The Peelle Motorstair

—for an improved escalator handrail

The assignment was a tough one – even to Goodyear experts in molded/extruded rubber. For the new handrail design proposed by this escalator manufacturer specified a grip intricately grooved to accommodate attractive metal or plastic inserts–key to a dramatic improvement over the strictly utilitarian escalator rails long in vogue.

Could rubber be molded to this complex design? What about the tough rubber-to-metal bond for fasteners, they asked the G.T.M.– Goodyear Technical Man – and his colleagues. Working together, the rubber experts and escalator men produced the answer: a rugged, articulated rubber rail grooved every half inch for the inserts–these to be offered in the user's choice of beautiful colors or finishes. And it's unspliced–yet far easier and less expensive to repair than any previous type.

And that's just one more example of the way better designs are made possible by molded rubber, extruded rubber and plastics developed in the modern Goodyear molded/extruded plants. Remember, these unmatched facilities with their skilled personnel and outstanding achievement are at *your* disposal.

For the complete story–or an invitation to see the Goodyear plants and laboratories, contact your local G.T.M. Or write directly to Goodyear, Industrial Products Division, St. Marys, Ohio, Los Angeles 54, California, or Akron 16, Ohio.

Watch the award-winning Goodyear Theater on TV every other Monday evening

MOLDED OR EXTRUDED GOODS BY

GOODYEAR

THE GREATEST NAME IN RUBBER

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Front Cover: Three kinds of misalignment—axial, lateral offset, and angular—can be accommodated by bellows joints, as shown by George Farnsworth's cover design. Article by C. M. Daniels, Page 146, tells how to choose the joint that is best suited for the job.

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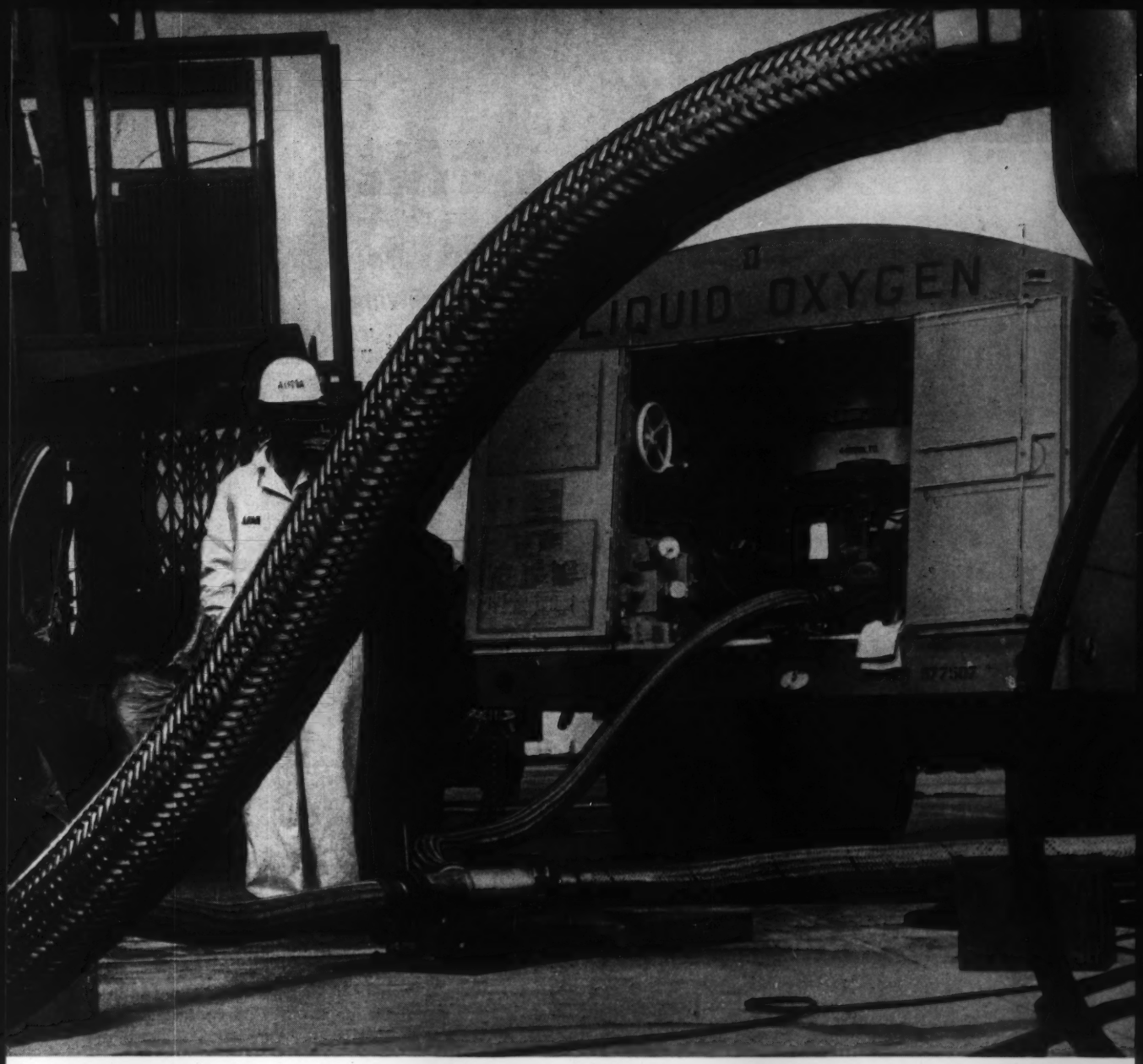

THESE BIG TOUGH HOSE ASSEMBLIES SOAK UP THE SHOCK OF A SWING FROM TROPICAL HEAT TO −303°F IN SECONDS

It takes many heavy-duty flexible metal hose connections to feed liquid oxygen to a missile. In the photo above are four 3½" I.D. metal hose lines of stainless steel manufactured by Anaconda Metal Hose. They connect three tank trucks to the pumping station which fuels Jupiters at the Army's Redstone Arsenal. Similar hoses are used to make connections between the fueling masts and the missile itself, making it unnecessary to align piping precisely. As fuel masts are kicked off the missile at firing, the hose must be able to withstand rough treatment and hot exhaust gases, as well as the wide temperature fluctuations.

FREE TECHNICAL SERVICE. Whether you need big, heavy-duty flexible metal connectors for big, tough jobs or small-diameter flexible metal hose for small, tough jobs, Anaconda Metal Hose Division welcomes the opportunity to help you meet your problems of expansion and contraction, movement, vibration, corrosion, pressures, and temperatures. Equipped to work in stainless steel, Monel, and aluminum as well as other alloy steels and copper alloys, Anaconda specialists are constantly working with design engineers on flexible connector assemblies to meet new problems. For further information or engineering assistance, call your Anaconda Metal Hose representative or write: Anaconda Metal Hose Division, The American Brass Company, Waterbury 20, Conn. In Canada: Anaconda American Brass Ltd., New Toronto, Ontario. 59131

ANACONDA®
METAL HOSE

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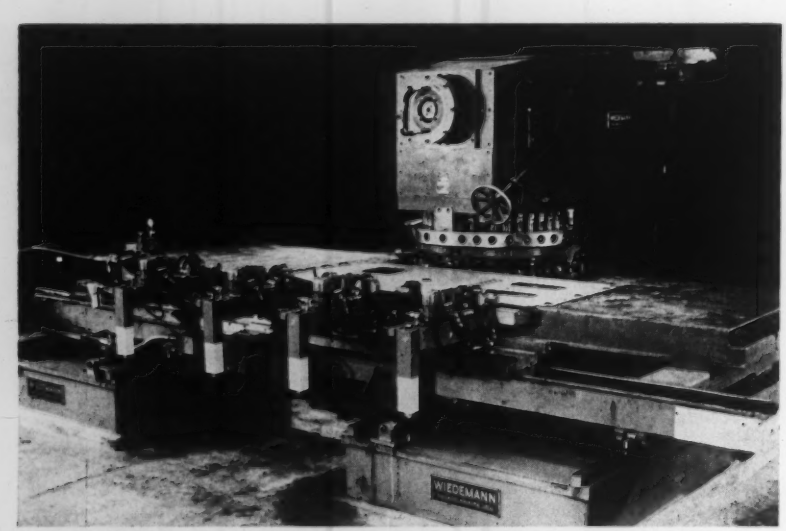
Programmer Makes Control Tape from Detail-Free Drawings

After the draftsman accurately locates templates on an outline drawing of the panel to be punched, he selects rotary turret punch positions for each template by operating switches on the machine's control console. Next step is centering a locating device (which uses lighted crosshairs) over centerline markings on the templates. A foot switch transfers X-Y co-ordinates of the centerlines to the magnetic tape.

The magnetic tape then goes to the shop where an operator mounts it in the turret punch press console. Press operations directed by the eight-channel tape are fast enough for the press to make 30 hits per minute.



The 36 different punches and dies carried in the turret range up to eight inches in diameter. Turret rotates as directed by the tape to bring the proper tool into piercing position in two seconds or less. Workholders move the panels into proper position at speeds up to 800 in. per min.

Taped Information Runs Punch Press

WAYNESBORO, VA. — Drafting time for detailing drawings can now be cut to a minimum. A new automatic programming device takes data right off a simplified drawing and puts together a machine-control tape. The tape runs a turret punch press, and eliminates any need for shop interpretation of drawings.

After the draftsman has accurately (but dimensionlessly) drawn a panel to be punched, he need only locate centers of holes, squares, etc. Using the programmer developed by General Electric's Specialty Control Dept., Waynesboro, he selects rotary punch positions for each cut and transfers this information to the tape. He then centers lighted crosshairs over center line markings of holes or other cuts to be made. Co-ordinates of the centers are transferred to the tape by a foot switch. The technique reportedly saves 75 per cent of drafting time required to prepare drawings for the shop. In addition, since the programming process is simply a matter of drafting mechanics, possibilities of human error are reduced.

After the tape is completed and checked, it is sent to the factory where it is inserted in the tape reader. Manual operations necessary in producing the work are limited to loading and unloading workpieces. The turret punch press, bossed by the tape, does the rest.

The turret punch press, companion to the programmer, is especially designed for high-speed work. Built by Wiedmann Machine Co., King of Prussia, Pa., the press will move workpiece blanks at speeds up to 800 ipm. Turrets rotate at a speed sufficient to bring one of 36 punches into piercing position in less than two seconds.

Both efficiency and speed of shop operations are improved by the automatic press.

. . . Fluid Power news

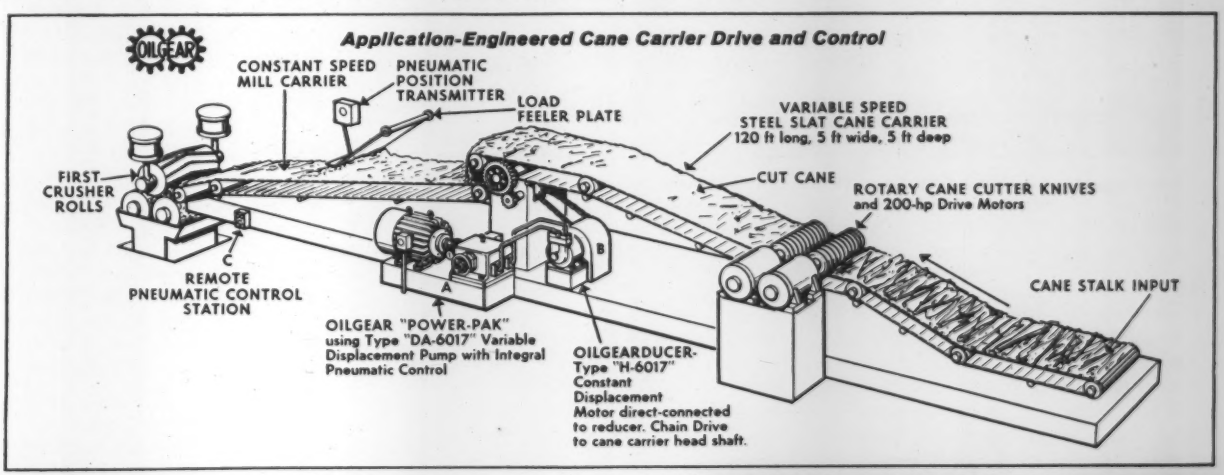
REPORT No. 11,302 "ANY-SPEED" DRIVE UPS MILL EFFICIENCY

From Oilgear Application-Engineering Files

HOW OILGEAR "Any-Speed" DRIVE AND CONTROL SYSTEM AUTOMATED A SUGAR CANE CARRIER

CUSTOMER: A Large Sugar Cane Mill (Name on request).

DATA: To increase mill efficiency, and run at maximum capacity by maintaining an optimum flow of cut cane to the crushers, it was necessary to convert a conventional, manually controlled electric cane carrier drive to an automatic, load-sensitive, variable speed drive and control system with the following specific requirements: 1. An infinitely variable speed drive coupled with automatic "sensing" load-speed controls to exactly match cutter and crusher capacity . . . plus instant-stop overload protection as required by the following variables: 1a. Inconsistent carrier loading. 1b. Varying size and physical characteristics of the cane. 1c. Cut cane's tendency to "choke" or pile up at the crusher. 1d. Gradual efficiency loss as cutter knives become dull. 2. Automatic speed control, and stop, related to load. 3. Remote and manual control to start, stop, inch, and infinitely increase or decrease carrier speed. 4. Pneumatic controls, as mill personnel understand them. 5. Dependable, trouble-free for round-the-clock harvest operation, impervious to high humidity and daily washdowns.


Application-Engineered Cane Carrier Drive and Control
OILGEAR
CONSTANT SPEED MILL CARRIER
PNEUMATIC POSITION TRANSMITTER
LOAD FEELER PLATE
VARIABLE SPEED STEEL SLAT CANE CARRIER 120 ft long, 5 ft wide, 5 ft deep
FIRST CRUSHER ROLLS
CUT CANE
ROTARY CANE CUTTER KNIVES and 200-hp Drive Motors
CANE STALK INPUT
REMOTE PNEUMATIC CONTROL STATION
OILGEAR "POWER-PAK" using Type "DA-6017" Variable Displacement Pump with Integral Pneumatic Control
OILGEARDUCER-Type "H-6017" Constant Displacement Motor direct-connected to reducer. Chain Drive to cane carrier head shaft.
A
B
C

SOLUTION: An Oilgear "Any-Speed" Drive and Control System consisting of an Oilgear "Power-Pak," an Oilgearducer, and the pneumatic control system as shown above. This "Power-Pak" uses a Type "DA" Variable Displacement Pump with integral pneumatic control, a constant speed electric motor all mounted on a custom reservoir base. The Oilgearducer consists of an Oilgear Type "H" Constant Displacement Motor direct-connected to a reducer. Operating on a pressure differential of 3 to 15 psi, the integral, pneumatic, pump control system provides stepless, infinitely variable drive speeds from zero to maximum. A completely automatic control system increases or decreases carrier speed in response to preset percentage of knife motor load, and position of the feeler plate on the mill carrier section . . . carrier is instantly stopped by sudden peak overloads on the knife motors, or by raising of the feeler plate above a preset position. Carrier can also be started, stopped, inched, accelerated or decelerated from the remote stations, or with the manual handwheel on the Pump.

OWNER REPORT — after two seasons of operation — *". . . . we began operations this season on January 9. We have been running under automatic operation since, and the results have been beyond expectations."*

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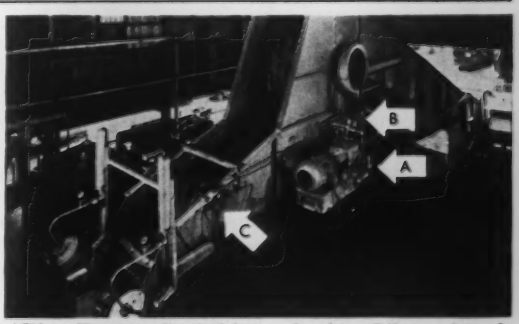

Right: A view of above installation. Oilgear "Power-Pak" (A), Oilgearducer (B), and one of the Remote Control Stations (C) are indicated.

Some of the "Plus Features" of this, and other Oilgear installations are: cushioned starts, stops, acceleration and deceleration . . . constant pressure and flood lubrication, and system fluid filtration . . . a "sealed" system, impervious to moisture-hazardous atmosphere . . . complete overload protection . . . long-life, trouble-free, efficient performance. Users say — *"for the lowest cost per year — it's Oilgear!"*

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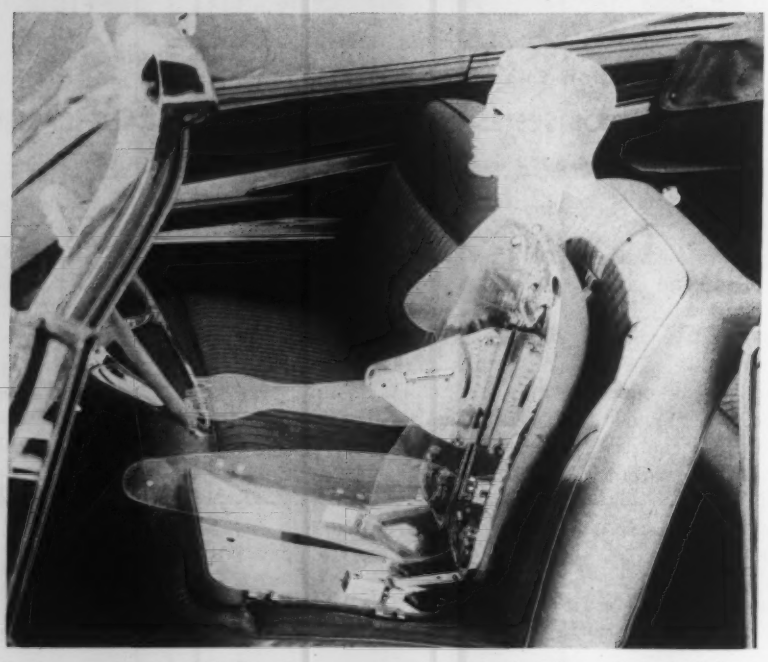


Seating angles in 1960 Chrysler cars were determined with the help of Sally—a plastic mannequin with articulated joints and comfort angles marked off like a protractor. Sally directed Chrysler engineers to raise driver's seats a full 4 in., re-position rear seats, and change cushion contours in most '60 models.

DETROIT—Despite opinion of a critical buying public, automotive designers have directed a fair share of their efforts toward making the new cars as comfortable as possible. Their accomplishments are meritorious in view of the obvious handicaps involved. Low-slung aerodynamic styling has reduced the floor-to-roof height in the average car to about 3½ ft. Getting the average man in and out of this package is a significant problem, let alone keeping him comfortably seated for several hours at a stretch.

To help design comfort into their '60 models, Ford engineers conceived a two-dimensional articulated mannequin called Oscar. Weighing 165 lb, Oscar is 69.5 in. tall and wears size-10 shoe (shoe size helps determine pedal spacing). He helped Ford investigate these factors associated with passenger seating:

- Posture characteristics
- Seat deflection
- Seat position

According to Oscar, a man sitting in the front seat of a car will slouch an average of 1 in; a man seated in the rear will slouch about 2 in.

Oscar further pointed out that the head is normally in a vertical position in relation to the neck and body, no matter how much a person slouches in the seat. In observing this phenomenon, Ford engineers went on to determine proper seat contouring and the correct angle of the seat itself. The latter, based on a vertical line drawn through the shoulder and hip joint, was optimum at 23 degrees.

Finally, Ford's dummy helped improve on an important standard long used in the industry. This is the "free *A* point"—a point 5 in. forward of the back seat and 15 in. from the centerline of the car body on the unloaded seat cushion. The "*A*" point has been used as a reference from which to measure headroom, but variability of seat deflection always complicates the problem for the designer. Using Oscar, Ford engineers came up with a new standard, the "deflected *A* point." This describes the vertical distance between the bottom of the seated passenger and the lowest point of his heel. Ford has determined that this distance should be 4.4 in.

Topics

The sack look may show up next in automobile gasoline tanks. B. F. Goodrich's Industrial Products Div. has developed a rubbery polyurethane plastic film which is strong enough to be used as a flexible gasoline holder in a car. Such a sack-type gas tank could be made to fit any open space in the car, would reduce weight, and would eliminate fabrication of a metal tank.

• • •

Crude measure of a dentist's touch has long been the victim's pain, but now strain gages do this job precisely in a new instrument which attaches to a dentist's drill. The strain gages, arranged radially about the drill's handpiece, are activated by pressure from the dentist's hand, and the pressure impulses are recorded. The instrument will aid in setting treatment standards by determining stresses which dental structures can endure in drilling. It was developed by a four-member research team from New York University's Colleges of Dentistry and Engineering.

• • •

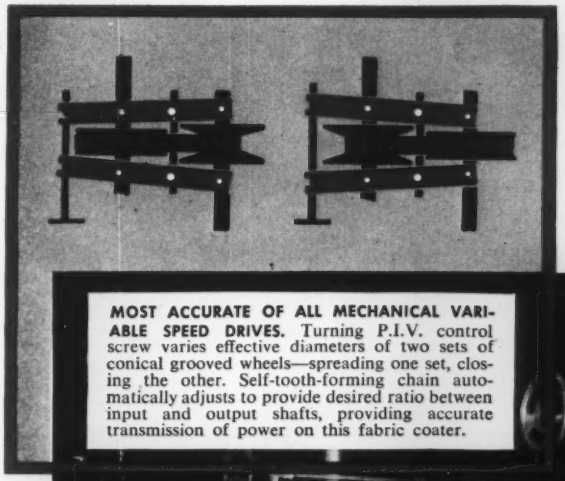
Another "collision-proof" auto body has been designed—this one shaped like a boat. William Brahmstedt has patented an oval-shaped vehicle with a low, pointed bow and a rounded stern. He feels cars of this design would not suffer from collision as do conventional ones, but would glance or slide off one another.

• • •

Box with a view—called a View Box—has been developed to satisfy Americans' desire to get back to nature yet remain comfortable. This structure is composed of structural aluminum channels, simple universal slide-in joints, and panels of aluminum and other materials. Channels and joints mesh to form a 16-ft square, 8-ft high View Box which can be added to at will. Panels form roof, floor, and side elements. Assembly—without tools—has been accomplished by a six-year-old and his mother. Not yet in production, the View Box was designed by John I. Matthias for the Aluminum Co. of America.

• • •

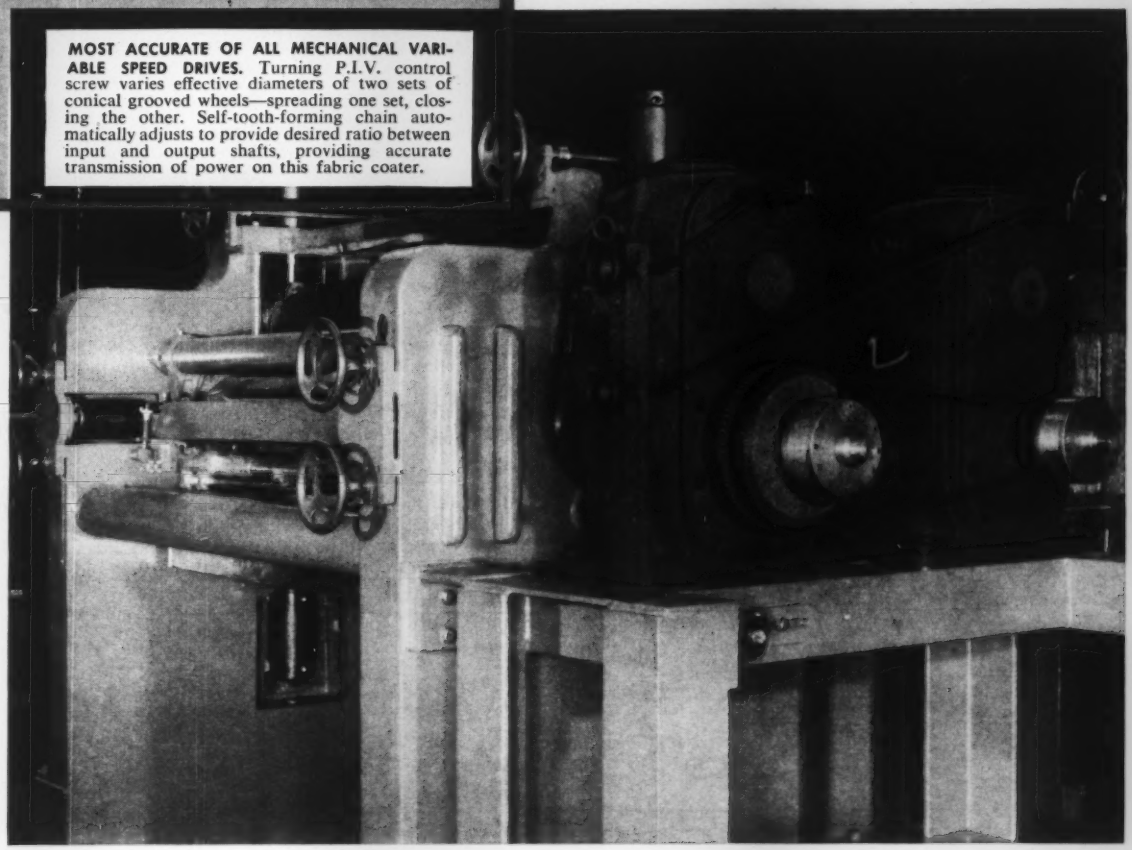
The tail-fin motif has spread from the highway to design of household appliances, according to Lippincott and Margulies, industrial designers. The firm attributes this trend to the fact that Americans are interested in "active" products that go places or get things done. Or, apparently, that look as though they will.



In principle . . .

in performance . . .

MOST ACCURATE OF ALL MECHANICAL VARIABLE SPEED DRIVES. Turning P.I.V. control screw varies effective diameters of two sets of conical grooved wheels—spreading one set, closing the other. Self-tooth-forming chain automatically adjusts to provide desired ratio between input and output shafts, providing accurate transmission of power on this fabric coater.



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. . . there's nothing like P.I.V.

Here's a variable speed drive that is truly unique. Unlike conventional designs, Link-Belt P.I.V. with its all-metal chain drive is *not dependent on friction* for transmitting power.

P.I.V. permits fast, easy speed changing too. You can select any speed in its range—find it instantly, hold it indefinitely. No bother stopping the drive.

Because Link-Belt P.I.V. (Positive, Infinitely Variable) drives are fully enclosed, atmospheric conditions can't affect their efficiency. They're made in 8 sizes, 16 standard types. Ask your nearest Link-Belt office for Book 2274.

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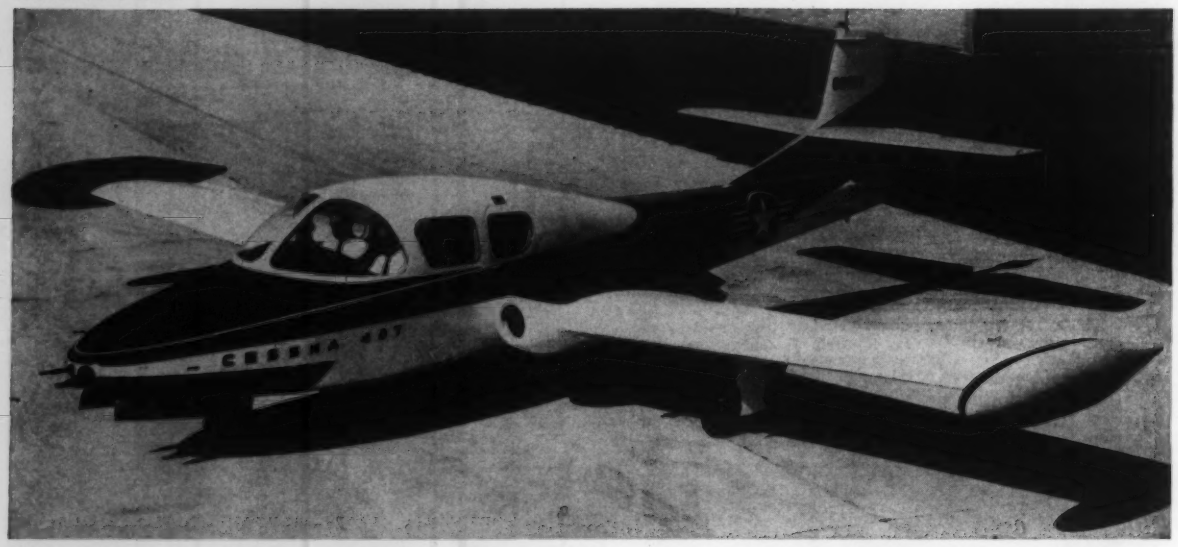
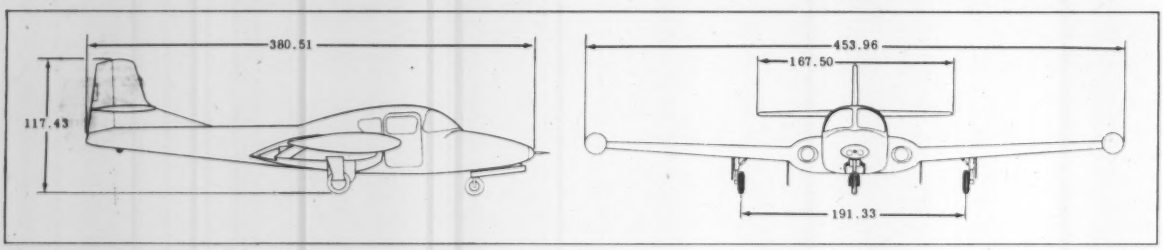


Economy Jet Will Use Trainer Parts

Military need for a low-cost utility transport prompted Cessna Aircraft Co., Wichita, Kans., to design this sleek, 4-place jet. Called Model 407, it boasts a cruising speed of 465 mph (top level-flight speed—487 mph) and a range of 1380 miles. Its comparatively low initial cost (about $200,000) is due to the design being based on proven parts from Cessna's T-37 jet trainer. Standard components of the T-37 are used with the exception of the cockpit section which has been redesigned to become a large pressurized cabin (pressure differential—7.5 psi at 35,000 ft) seating four passengers with baggage. Continental J-69 powerplants, qualified to produce 1700-lb thrust each, are derated to 1400 lb, assuring long engine life. Service ceiling is 46,400 ft; rate of climb is 3680 fpm. The jet will take off within 2850 ft (50-ft obstacle), land within 3050 ft, and has a stall speed of 96 mph. Cessna's current plans are to obtain contracts before placing the new airplane in production. The company does not expect civilian applications unless military contracts bring down costs. Picture shows full-size, nonflying mockup.



Research Yields Surprises On Atomic Spacings

Sacred Cows Fall by the Wayside

ITHACA, N. Y.—Atoms in gaseous molecules at very high temperatures are often bunched closer together than atoms in solids at low temperatures. This is one of several conclusions drawn from Cornell University research conducted by an international team of scientists.

In many substances, atoms stay close together when the substance becomes gaseous, and are still close together when temperatures get up to 1000 K. Also, the traditional belief that atoms in the gaseous state are broken apart into the smallest of fragments is apparently incorrect. They have a tendency to clump in pairs, triplets, and more complicated groupings.

In the Cornell studies, an improvised electron diffraction apparatus measures distances between atoms in various substances. Conversion of the apparatus for high-temperature work (during the last year) has led to a new frontier in basic research —a frontier that should directly affect thinking on problems of intense heat in space travel.

The high-temperature electron diffraction unit is the first of its kind outside the Iron Curtain—the Russians are known to be pursuing such research. With it, molecular structures are determined from diffraction patterns produced when a narrow, 50,000-v beam of electrons is scattered by passing it through a "molecular jet." The patterns, spacings, and intensities of concentric rings formed on photographic plates are related to the scattered electron intensities, and are measured by microphotometric techniques. Computations are performed by computer. Other studies use shock tube and mass spectrometer methods.

National Science Foundation has awarded Cornell an 18-month, $20,000 grant to further this work.

CASE HISTORIES

Two precision ball bearings, one concentric within the other, are periodically rotated in alternating directions during operation—thus reducing random drift to 0.25 degree per hour.

Photo: courtesy Sperry Gyroscope Co.

1,200% Gain In Gyro Accuracy With N/D Ball Bearings

CUSTOMER PROBLEM:

Get new, advanced gyro bearing design "off the board" and into production. Sperry Gyroscope Company, in developing its new Rotorace (TM) gyro, designed a special bearing capable of "averaging out" error-producing effects of friction on sensitive gyro gimbals. New manufacturing techniques would be required to achieve high degree of precision required by Sperry design.

SOLUTION:

N/D Engineering, when approached by Sperry, created special manufacturing techniques for the high precision production of these unique piggy-back gimbal ball bearings. Used in the Rotorace design, the bearings helped achieve reduction of the gyro's random drift rate. The 2 or 3 deg. per hour drift, recently considered very good, is now cut to as little as 0.25 deg. per hour, with still lower rates in sight. Another example of New Departure's ability to meet exacting instrument bearing requirements through broad engineering experience and precision manufacturing techniques.

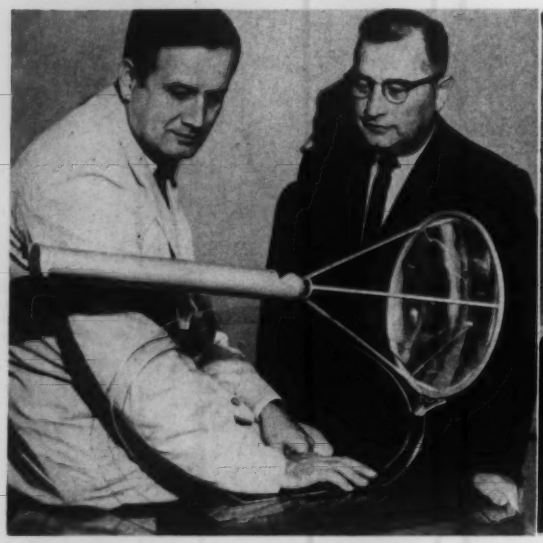
For immediate engineering analysis of your current high precision instrument and miniature ball bearing problems, write Dept. L.S., New Departure Division, General Motors Corporation, Bristol, Connecticut.

NEW DEPARTURE

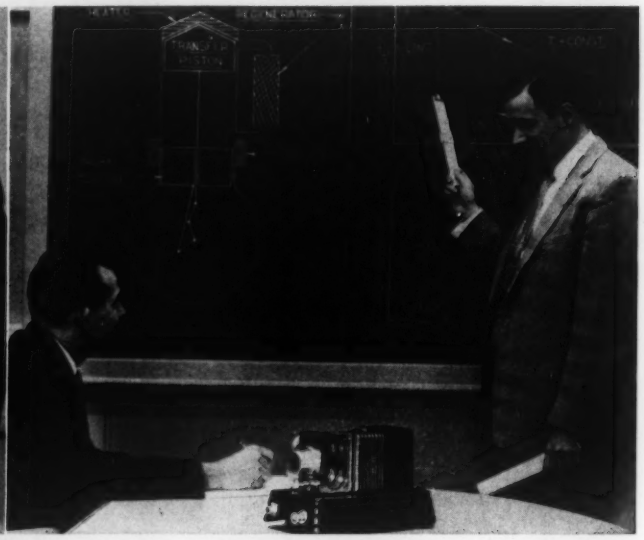
BALL BEARINGS

proved reliability you can build around

Closed-Cycle Engine Attains 40 Per Cent Efficiency



Satellite version of air engine, powered by solar energy, may have a 20-ft plastic Fresnel lens like that in the model to focus sun's rays on the heat trap. Engine will also carry a lithium hydride heat battery to store energy for use while the satellite is in the earth's shadow.



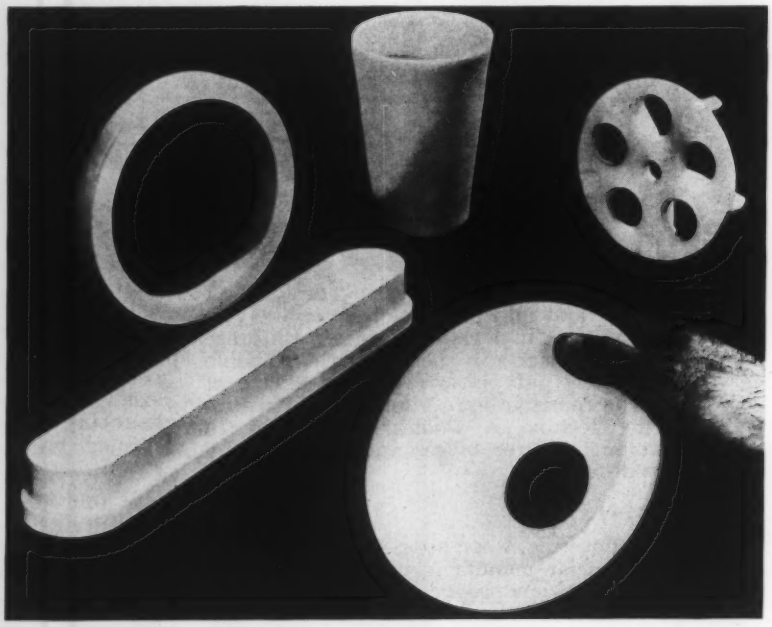
Laboratory test engine, which shows 40 per cent efficiency, may be the prototype for stand-by generator powerplants, as well as motors for lawn mowers, outboard motorboats, and air conditioners. Internal diagram of engine is seen on the board; power cycle plot is at right.

INDIANAPOLIS—Powerplant for a future satellite may be a captive gas reciprocating engine that could run unattended for two years or more. Principle for the engine was worked out by a Scottish clergyman, Robert Sterling, in 1816, so it is hardly new. But modern thermodynamic analysis has changed a bulky curiosity into a streamlined laboratory model with an impressive 40 per cent efficiency. A Sterling cycle engine of one cubic inch displacement can generate 1½ hp.

American developer, Allison Division, General Motors, foresees its use in lawn mowers, outboard motors, and garden equipment. Vibrationless operation and use of a wide variety of fuels makes the engine a good candidate for quick acceptance by the general public.

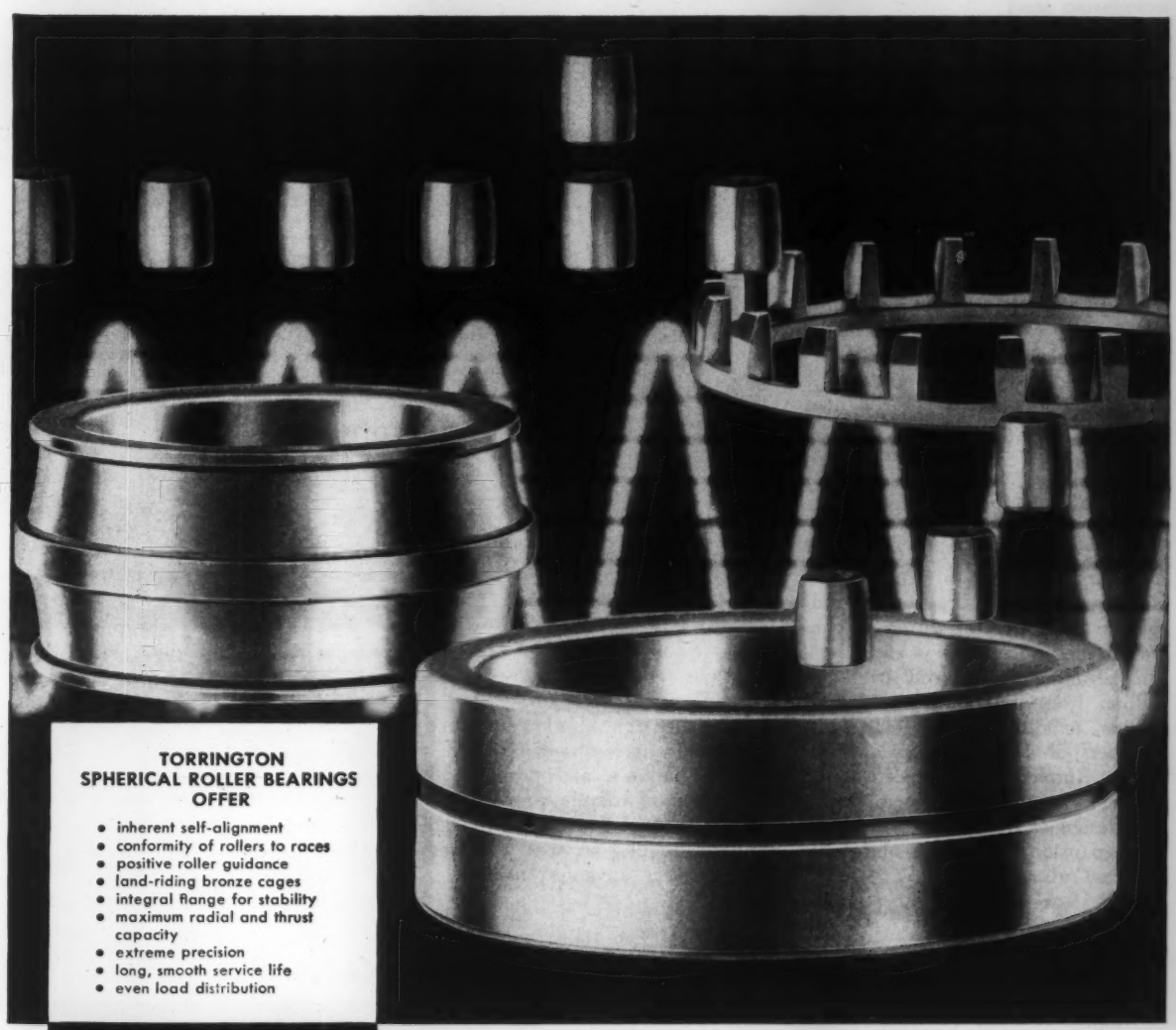
External heat in the form of solar energy, or the combustion of almost any fuel, is applied to the heat trap in the engine to start the cycle. Two pistons driven by the expanding and contracting air transfer energy to a crank to produce rotary motion.

Refinement of the Sterling cycle engine was done by N. V. Philips Gloeilantenfabrieken, Eindoven, Holland. Allison's development is under an agreement with Philips.



Fused Silica Gets New Look

New sizes and shapes of fused-silica structures can now be produced. Cylinders, domes, crucibles, slabs—all are made possible by a new forming technique developed by Corning Glass Works, Corning, N. Y. Any geometry possible with lesser ceramics can now be formed in fused silica. The technique should open new applications to the high-purity material, since it has the ability to withstand long-term exposure to 1700 F and intermittent exposure to 2250 F.



TORRINGTON SPHERICAL ROLLER BEARINGS OFFER

- inherent self-alignment
- conformity of rollers to races
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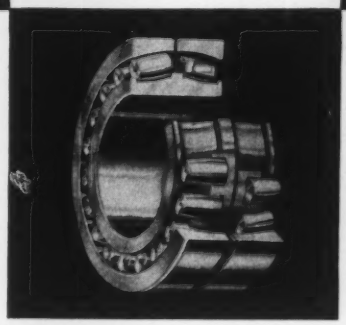
- land-riding bronze cages
- integral flange for stability
- maximum radial and thrust capacity
- extreme precision
- long, smooth service life
- even load distribution



Electronics Matches Rollers and Races for Extreme Accuracy

Torrington employs the latest electronic techniques to insure precise geometric relation between components of Torrington Spherical Roller Bearings.

Roller diameters of a given complement are matched within .0001″ of each other. For ultra-precision bearings, tolerances are even closer. Inner and outer races are as rigorously classified. Components are selected for assembly to provide accurate diametrical clearance. The result is bearings of unparalleled accuracy for minimum wear and friction, smooth operation and long service life.

Torrington's care for these details of accuracy is matched only by our care in matching the *right* bearing to the *right* job. In this, you can rely on your Torrington representative and the facilities of Torrington's Engineering Department. **The Torrington Company, South Bend 21, Ind.—and Torrington, Conn.**

TORRINGTON BEARINGS

District Offices and Distributors in Principal Cities of United States and Canada

SPHERICAL ROLLER • TAPERED ROLLER • CYLINDRICAL ROLLER • NEEDLE • BALL • NEEDLE ROLLERS • THRUST

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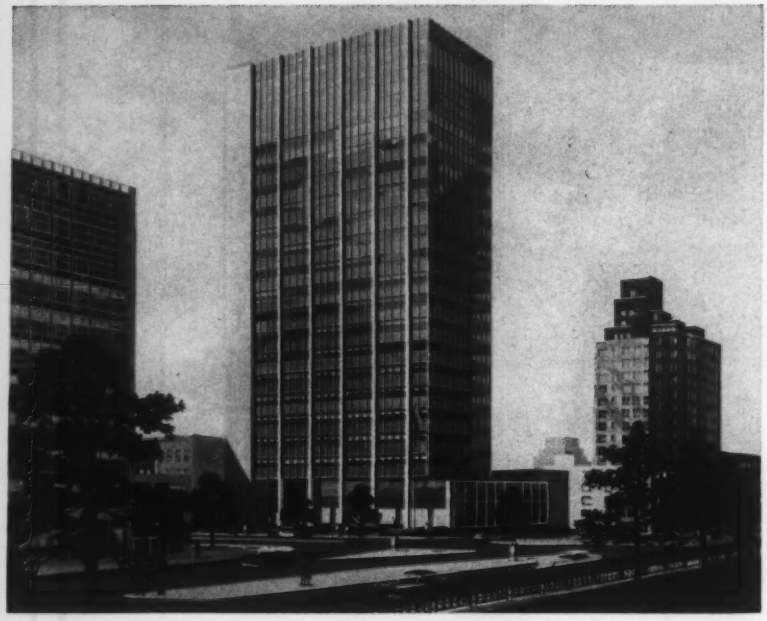
Construction Begins on United Engineering Center

NEW YORK—A new and important milestone for the engineering profession was passed on October 1 with ground breaking for the United Engineering Center. The $12 million, 18-story structure will house the headquarters staffs of 18 major engineering societies having a combined membership of some 300,000. Together, the societies are responsible for a major part of the nation's technical publications, industrial standards, and engineering conferences. Some of the groups are now housed in the old Engineering Societies Building in New York.

Plans for the Center, scheduled for completion in 1961, have been eight years in the making. Fund raising is about two thirds of the way home—$5 million in contributions from industry and over $2 million from individual engineers.

First tenants will be 600 staff members of 18 societies and joint bodies. Ample space has been allotted for numerous conference rooms, and design of the Center will allow for expansion to accommodate the expected future growth.



Future home of 18 major engineering societies will be this glass, metal, and limestone tower rising above United Nations Plaza in New York City.

The Center's library, in greatly expanded quarters, will continue to be the nation's, and probably the world's, most complete repository of engineering knowledge. Indexing and abstracting services will incorporate every advanced facility.

United Engineering Trustees Inc. will own and operate the Center on behalf of the engineering societies. The structure will occupy a full block on United Nations Plaza (First Ave.) between 47th and 48th St. in New York City.

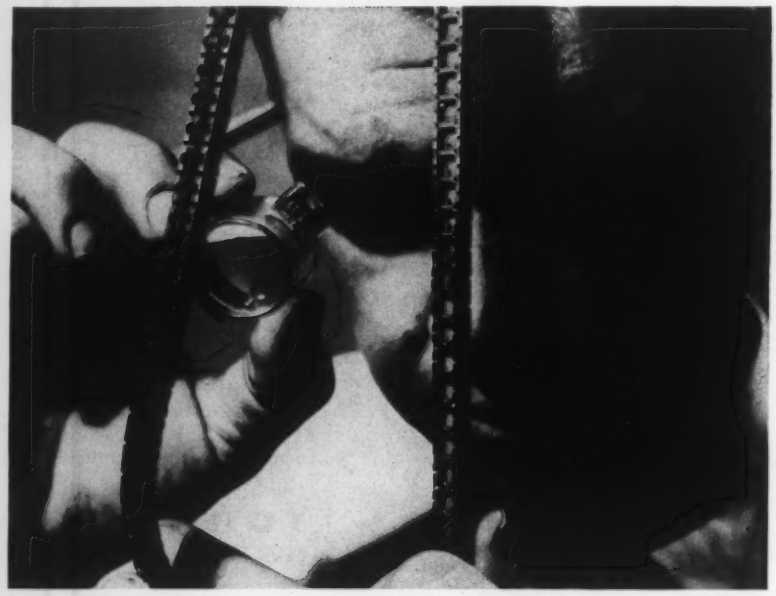
Fast "Readers" Keep in Step with High-Speed Computers

Unique Designs Upgrade Data-Recording Systems

CLEVELAND—As computing equipment speeds up by leaps and bounds, it continually threatens to outrun the capabilities of read-out and recording systems. Two new devices: A unique printer, developed by IBM, and a photo recorder, developed by Eastman Kodak Co., are designed to keep the gap from widening too far.

IBM's Type Chain

The heart of IBM's new 1403 Printer is a fast-moving horizontal chain of engraved type faces, operated by 132 electronically timed hammers spaced along the printing line. A scanning device compares characters on the chain with characters in storage designated to be printed. When a character on the chain matches the one in storage,



Moving chain of engraved type faces is the key to a new high-speed data printer. Chain assures alignment of printed lines and cuts number of characters needed.

the hammer for that printing position is fired. Impact of the hammer presses the paper and ink ribbon against a type character. The type chain moves across the face of forms or documents at a constant speed of 90 in. per second.

An unusual feature of the printer is its so-called Dual Speed Carriage, which has the ability to skip over blank spaces on forms and documents at speeds far in excess of normal printing rate. The carriage skips the first eight blank lines at thirty-three inches per second, and beyond eight lines, at 75 in. per second. Combined with a printing speed of 600 lines per minute, the result is a higher rate of output than is obtainable with many printers of greater line-printing speed. The 1403 can produce over 230 two-line documents per minute which is equivalent to a printing speed of 4800 lines per minute.

All electronic and logical operations of the Printer are under the stored-program control of a separate processing unit. Information to be printed is read into storage from the input cards or magnetic tape, processed, and read out to the Printer.

Kodak's Camera

The high-speed recording system developed by Eastman Kodak Co. combines magnetic tape and microfilm. Called Dacom, for Datascope Computer Output Microfilmer, the system is designed to cope with the tremendously high ouput of electronic computer data which frequently requires magnetic tape for storage and a separate and subsequent decoding operation.

Dacom "reads" magnetic tape and displays the corresponding letters or numbers on the face of a cathode-ray tube. A special camera continuously photographs the face of the tube to put a complete page on microfilm.

The system has a speed of 16,500 characters per second and can reproduce 66 lines of 130 characters on a page. It can record 6900 lines per minute, and a 1000-ft roll of 16mm film will contain the decoded information from more than 35 reels of 2400-ft magnetic tape.

Dacom is currently under development at Kodak's Apparatus & Optical Div., Rochester, N. Y., and is not yet available commercially.

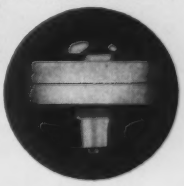
Townsend Lockbolts now available in Stainless Steel for greater strength ...corrosion resistance

If you need extra strength in fastening your assembly—plus corrosion resistance—you can get both now with Townsend 18-8 stainless steel lockbolts.

The use of Townsend stainless lockbolts gives you greater flexibility of design and the values are highly uniform. There is no chance for human error in setting lockbolts. Men with no special training get strong, vibration-proof joints every time.

Townsend stainless lockbolts are vastly easier to install —for example, they eliminate the back breaking work of bucking stainless rivets which work-harden rapidly.

Townsend lockbolts are also available in carbon steel and aluminum alloy in a wide range of diameters and grip lengths in brazier, button and 90° countersunk head styles. Write today for information to Engineered Fasteners Division, P.O. Box 71-E, Ellwood City, Pennsylvania.



Licensed under Huck patents RE 22,792; 2,114,493; 2,527,307; 2,531,048; 2,531,049 and 2,754,703

Townsend Company

Engineered Fasteners Division

ELLWOOD CITY • PENNSYLVANIA

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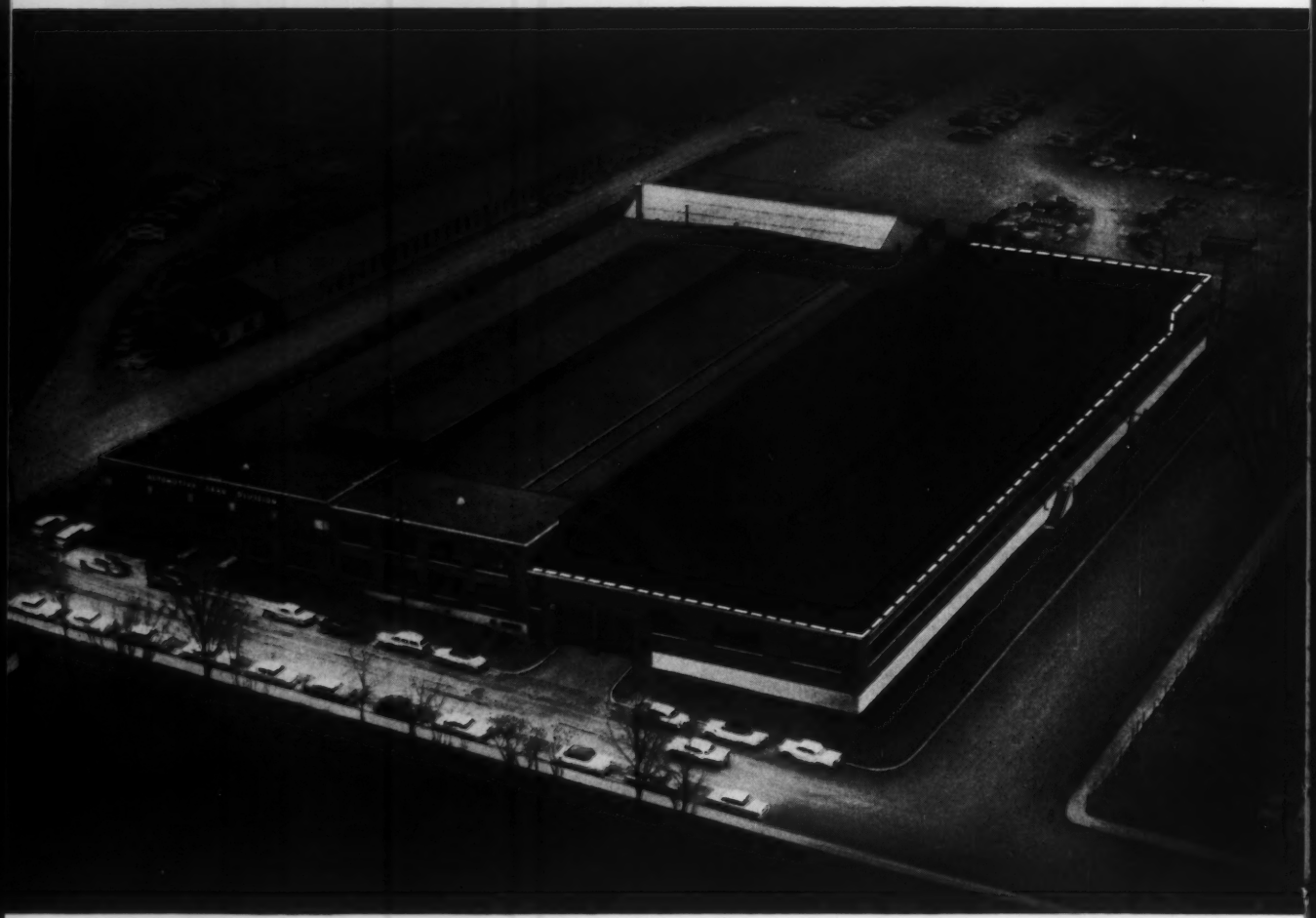
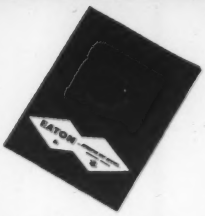
THIS MUCH MORE in '59

Expansion was not the order of the day during the past year, but it was in this period that the growing sales of "Double Diamonds" required the addition of 60% more manufacturing space. Hence, we now enter the more promising future with better and more facilities to serve as your "gear department" or to fill your gear orders with "Double Diamond" Gears that are built *to produce low installed cost... to serve economically and dependably on the job for which you buy them... and to do credit to your product and your reputation.*



May we send you this catalog of the gear types in which we specialize: helical gears, flywheel starter gears, straight bevel gears, straight spur gears, angular bevel gears, hypoid bevel gears, gear assemblies, zerol* bevel gears, spiral bevel gears, and spline shafts?



*Reg. U. S. Pat. Off.

EATON

AUTOMOTIVE GEAR DIVISION
MANUFACTURING COMPANY
RICHMOND, INDIANA

GEARS FOR AUTOMOTIVE, FARM EQUIPMENT AND GENERAL INDUSTRIAL APPLICATIONS
GEAR-MAKERS TO LEADING MANUFACTURERS

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CIRCLE ITEM NUMBERS—Throughout the magazine, each advertisement carries an Item Number for use in requesting further information. All product descriptions, announcements and Helpful Literature items are also numbered, and for greater convenience are indexed below by Item Numbers.

EDITORIAL CLIPSHEETS—So you won't have to "clip" this issue, we'll be glad to send a personal copy of any article as long as the supply lasts. Just fill in the page number and title of article in the place provided on the Yellow Card.

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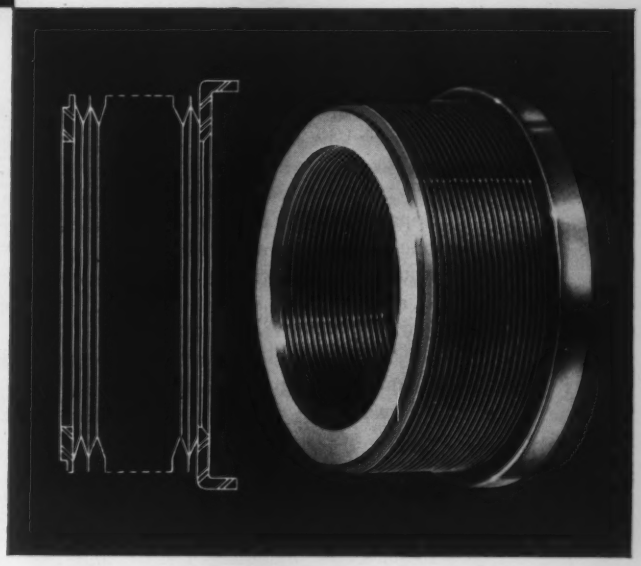
C/R DESIGN NOTES

How C/R's New Metal Bellows Seal Meets Seemingly Impossible Operating Conditions



Operating Ranges

Temperature	−400° to 1000° F.
Pressure	500 psi
R.P.M.	80,000 plus

These known operating ranges indicate the function of this seal. It is designed for applications where temperatures and mediums to be sealed forbid the use of any organic materials. Typically, these applications include fuel pumps, compressor power units and turbine starters characteristic in rockets and missiles. Other applications include mechanisms which are exposed to a high level of radioactivity.

Design Advantages

The C/R metal bellows seal consists of a metal bellows — a welded homogeneous unit which is secured at one end — and a carrier ring in which the sealing face is mounted. The seal does not contact the shaft. It is stationary, and the only rubbing surfaces are the sealing face and mating ring. These surfaces are precision lapped to provide a positive seal with minimum friction. At any given pressure, the seal can be designed to maintain proper and constantly effective face loads. It orients immediately to run-out and will resist any torques it is subjected to in operation. The design has high end-play tolerance: Chicago Rawhide engineers have deflected a bellows .100 in. for three million cycles at 1750 cpm and at a temperature of 500° F. with no adverse effects.

A further advantage is relatively light weight and compactness. The C/R metal bellows seal can be designed for minimum axial and radial space. Axially, complete seals can be produced within a ¼ in. cross-section. Radially, dimensions are comparable with conventional end face seals.

The C/R metal bellows seal can also be designed with an extremely low coefficient of expansion. The importance of this factor becomes apparent with the fact that in many applications the operating temperature may change hundreds of degrees in a very few seconds.

Mediums To Be Sealed

Virtually any known liquid or gas may be positively sealed with this design, depending upon duration or service life. From a practical viewpoint, the C/R metal bellows seal is the best design for the sealing of cryogenic and high-energy fuels such as LOX, hydrogen peroxide, fluorine and other missile and rocket propellants.

Where possible, lubrication of the two sealing faces is desirable to prolong service life. However, the medium being sealed commonly acts as the lubricant and may be merely hot gas.

Materials

Sealing faces and mating rings for the C/R metal bellows seal are available in a variety of materials including carbons, carbides, ceramics and various alloyed metals for both high temperature and corrosion resistance. The bellows can be furnished in any of several metals and alloys such as stainless steel, Monel, Inconel X, Ni-Span C and other special alloy steels.

Consult C/R Engineers

Each application for the C/R metal bellows seal is essentially a custom-design and an intimate knowledge of all conditions to be encountered must be known by Chicago Rawhide engineers to produce the correct combination of properties in the seal. Then, whether you require five, fifty or five thousand seals, Chicago Rawhide will design and produce the correct seal to solve your problem.

Helpful Design Data:

We will gladly furnish you with a design guide and space envelope data concerning the C/R Metal Bellows Seal. Just write for Bulletin MBS-1 on your company letterhead.

CHICAGO RAWHIDE MANUFACTURING COMPANY

1221 Elston Avenue • Chicago 22, Illinois

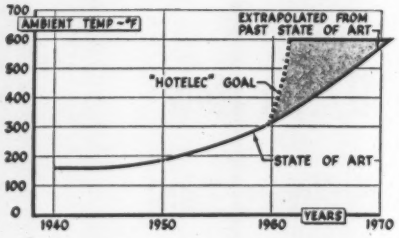
Offices in 55 principal cities

In Canada: Chicago Rawhide Mfg. Co. of Canada, Ltd., Brantford, Ontario

Export Sales: Geon International Corp., Great Neck, New York

Circle 413 on Page 19

"Hotelec" makes progress



Airborne electrical systems able to operate in 600-F ambients will probably be available by 1962, thanks to Air Force dollars. The AF got into the act because extrapolation of current progress rates indicated a 600-F system would not otherwise be ready until at least 1970, said J. J. Pierro, North American Aviation Inc., at the SAE National Aeronautic Meeting. Although the project, called "Hotelec," is coming along nicely, materials and other problems still remain to be solved. There is little doubt, however, that such a system is feasible.

machines and customers will run new post offices

Automated, customer-operated post offices will begin operation in several major cities, including Detroit and Denver, early next year. Equipment for the new installations is presently being procured and evaluated by Food Machinery & Chemical Corp., San Jose, Calif. Equipment will include a "facer-canceller" which electronically identifies stamps and turns envelopes so they will be properly cancelled; an automatic address reader, using electronic scanning, to sort mail; and a parcel-post sorter with a memory for insurance figures, handling instructions, and destination.

film-thick FEP insulation due

Next generation of electric and electronic insulation will probably be synthetic films. First to be offered is a Teflon film developed by Du Pont and scheduled for commercial production early next year. The thermoplastic film belongs to the newly developed FEP-fluorocarbon resin family, rather than the older TFE-fluorocarbon group (they differ in melt-flow properties). Reportedly, the film has excellent heat, chemical, and electrical resistance (dielectric strength of a 1-mil film is about 3200 volts), is cheap (about 17 cents per sq ft in 1-mil thickness), and is easily fabricated. It will probably find application in coil-wound devices, capacitors, wire and cable, and rigid and flexible printed circuits.

more or less about engineers

The Soviet boast that Russia is graduating three times as many engineers as the United States should not panic the nation. We do not need to play the "numbers game" says Harold A. Mosher, president, National Society of Professional Engineers. Even though the Russians claim that during the next seven years they will graduate 2,300,000 engineers, this claim is of little importance. "It would be tragic if we let a few well-publicized numbers throw us off this track and back into a race to see which nation can graduate the most engineering 'bodies.' One quality engineer may get us to the moon faster than a hundred quantity engineers." Primary needs are at the poles of the engineering forces—advanced knowledge acquired through graduate study, and engineering technicians.

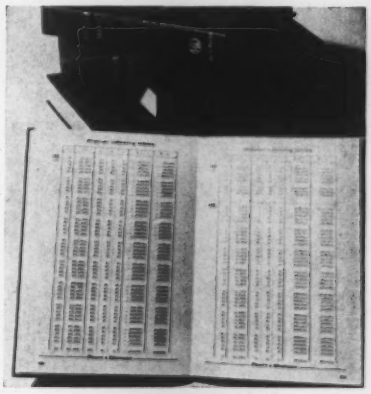
electronics: airing internal problems

The tunnel diode—the new semiconductor device that controls electron flow—will not outdate older electronic circuit components, according to Edwin E. Parker, general manager, General Electric Instrument Dept., West Lynn, Mass. It will complement rather than replace the transistor. Although the tunnel diode is 100 times as fast and requires only 1/100 as much power, the two will lead to smaller, more efficient electronic devices. One device now "possible" is a pill-size radio transmitter "so small you could swallow it and have a doctor diagnose your illness from the telemetered output."

bomb-powered rocket research progresses quietly

Feasibility of powering a rocket by controlled nuclear explosions will be determined in several months. Scientists working on Project Orion (official code name for "nuclear-pulse" propulsion) are scheduling an A-bomb blast to prove recent "highly encouraging" theoretical developments. Orion's concept is obvious and simple, but the hardware involved staggers the imagination. One leading proponent suggests this eventual configuration: A space vehicle 800 ft long carrying a bulb-like thrust chamber 240 ft in diameter. Small A-bombs, shot into the chamber at 1-sec intervals, would explode and cause the air to expand suddenly. At sea level the chamber would contain 270 tons of air, and the resulting thrust would be 100,000 tons.

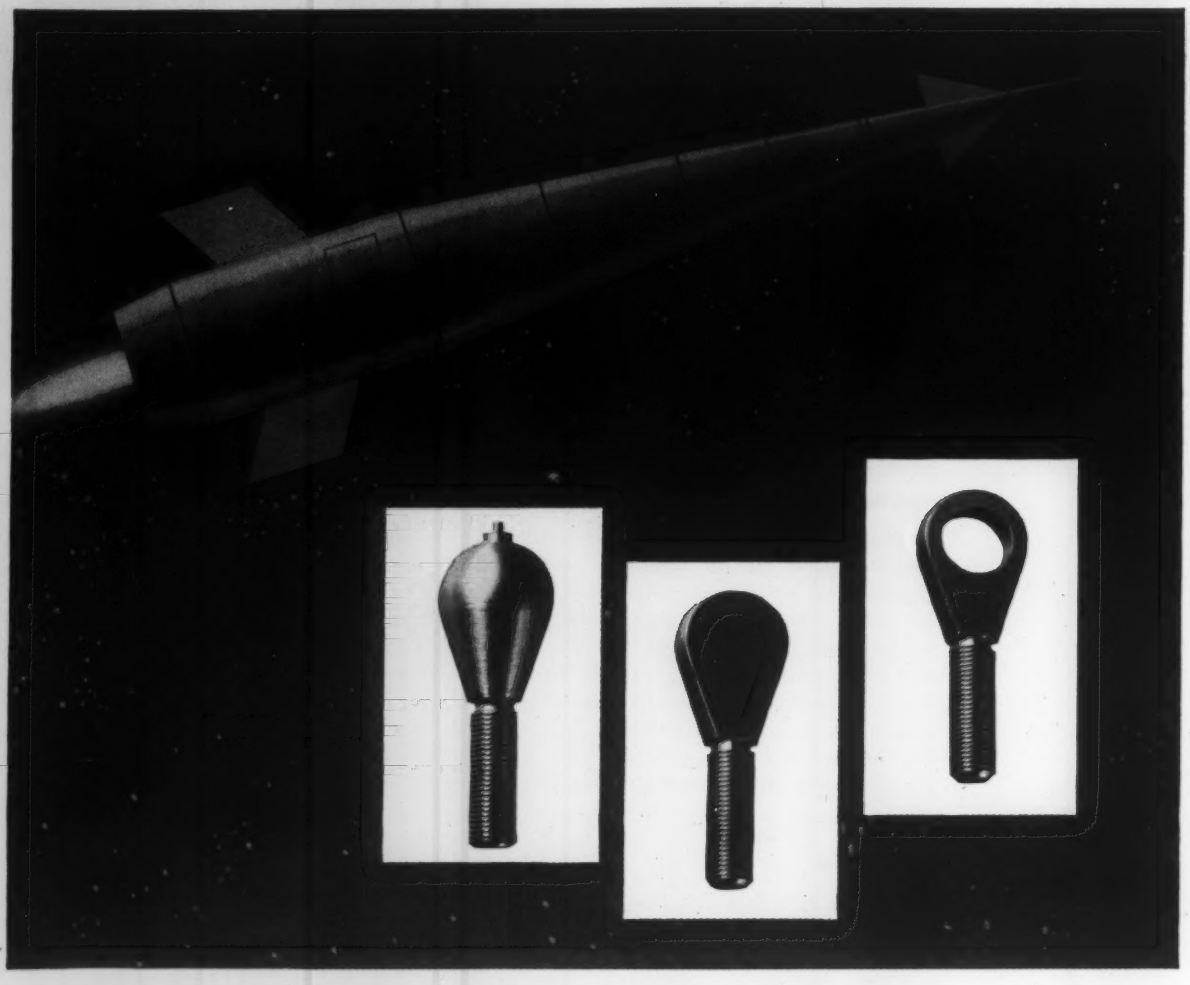
plug-in author



Latest book published by Pratt & Whitney Co. Inc., West Hartford, Conn., is a technical effort written by a computer. Like Hemingway, the computer uses a precise style without excessive adjectives. And instead of prose, it writes a numeric language—to 15 decimal places. *Angular Indexing Tables,* title of the computer's first literary effort, would have taken two crackerjack mathematicians a year or two at least to write. The computer did the job in 112 hours. The book consists of precise tabulations for dividing a circle from 2 to 210 equal divisions. For each of these divisions, the decimal value; degrees; minutes and seconds; and the sine and cosine are given.

heat pump finds a home

The heat pump—that combination heating and air conditioning unit long heralded for home comfort—has finally found its way into a housing development. The Air Force 800-dwelling project at Myrtle Beach, S. C., will be equipped with 2 and 3-ton units designed by Westinghouse Electric Corp. The indoor sections of the units will be placed in attics, and the outdoor sections at the rear of the homes. Cool or warm air (depending on the season) will move through ducts and pass into the rooms through ceiling vents.



for strength, corrosion resistance, machinability

and quality finish . . . **it had to be stainless**

The fabricator made this critical missile part much more reliable by switching from a cadmium plated alloy steel to Carpenter Stainless No. 5 (Type 416). He also eliminated rejects (they had averaged 25%), lowered production costs and increased output nearly 100%.

All applications of Carpenter Stainless aren't as spectacular as this, but the results in nearly all cases are proving so beneficial to both fabricator and customer that "Carpenter Stainless" is seen on more blueprints every month. Carpenter has the knowledge and experience to help you make the profitable switch. Contact your nearest representative now. The Carpenter Steel Company, Reading, Pa.

Carpenter steel

The Carpenter Steel Company, Main Office and Mills, Reading, Pa.
Alloy Tube Division, Union, N. J.
Webb Wire Division, New Brunswick, N. J.
Carpenter Steel of New England, Inc., Bridgeport, Conn.

Circle 414 on Page 19

Design changes — inevitable in almost any field — are particularly expensive with short-run parts molded of plastic. A $2000 one-piece mold can't be scrapped at a designer's whim. That's why some fabricators are turning to

Choice of low density polyester for this depth indicator case (by Pearce-Simpson Inc., Miami, Fla.) was based on appearance, corrosion resistance, and low molding costs . . .

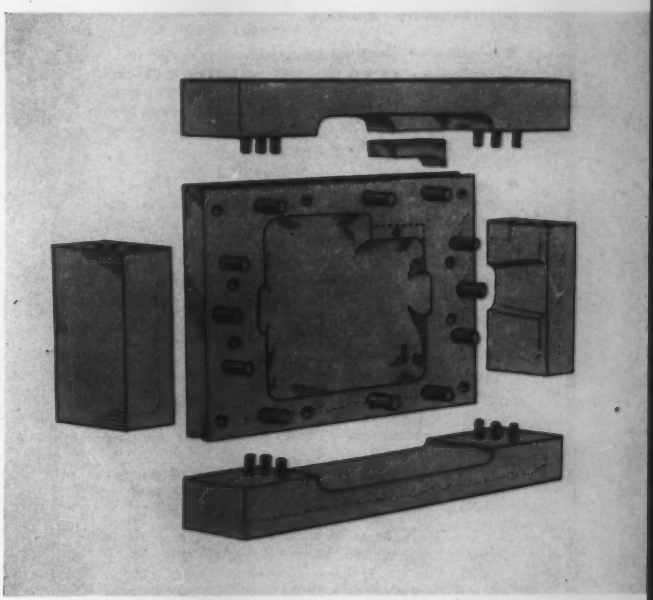
Building-Block Molds for Quick Product Changes

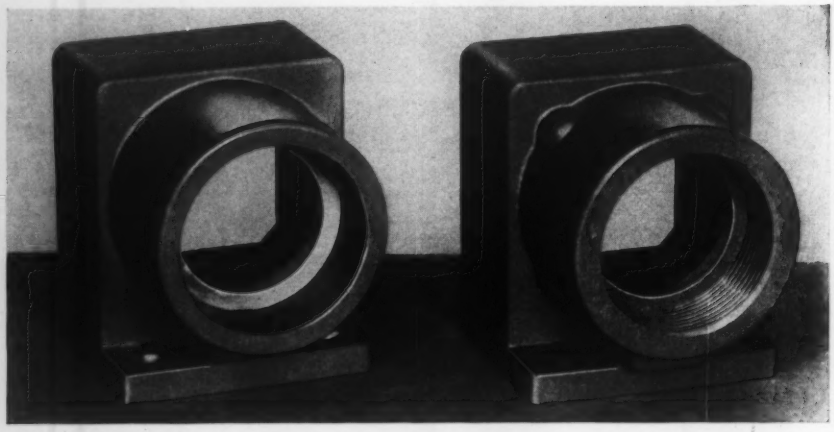
CARL ZEHR
President
Carl Zehr Co.
Ashtabula, Ohio

UNIQUE PROPERTIES of recently developed low-bulk molding compounds have opened the doors to new possibilities in plastic product design. These materials, even with their relatively high glass content, flow readily in the mold. This allows molding under low pressures (500 psi average) in inexpensive built-up molds similar to those used in the rubber industry. The contrast in costs between one-piece and built-up molds is startling: A high-pressure phenolic-type mold that cost $2000 can be constructed for molding at low pressure by the building-block technique for only $400. The designer can get the benefits of molding even for short runs (100 to 300 pieces).

By calling for low-bulk glass-re-

. . . **Female member of the mold** consists of six distinct parts. Machining of individual parts required approximately one sixth the labor of a similar one-piece mold.





Design changes in plastic housing for infrared detector control were incorporated in built-up mold (far right) for $44. Old inserts were saved so that parts could also be made to original specifications. Euclid Electric & Mfg. Co. paid $350 for the mold—changes and all. Conventional high-pressure mold would have cost $2500.

inforced polyester premixes,* the designer can obtain other advantages that are less obvious:

- Modification of part design at insignificant cost in mold alterations.
- Reduction of time from the final blueprint stage to initial production.
- Desirable physical and chemical characteristics in the part (such as high strength, corrosion resistance, and dielectric properties.)

In a built-up mold, the various contour elements are shaped individually on standard machine tools and then assembled like building blocks. The need for high-pressure molding (2000-5000 psi average) has prevented the use of this technique on plastics up to now. Mold construction for the plastics industry has been controlled by the requirements of phenolic-type compounds. The resulting molds are extremely expensive.

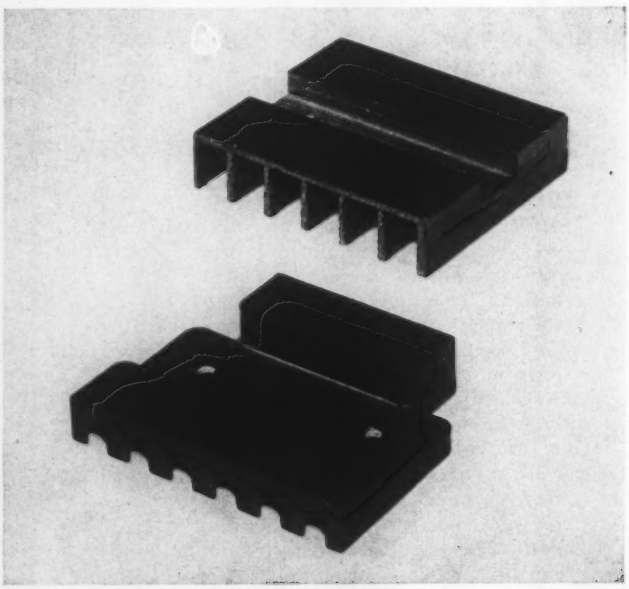
*For example, Thermaflow materials manufactured by Atlas Powder Co., Wilmington, Del.

Where Mold Costs Come From

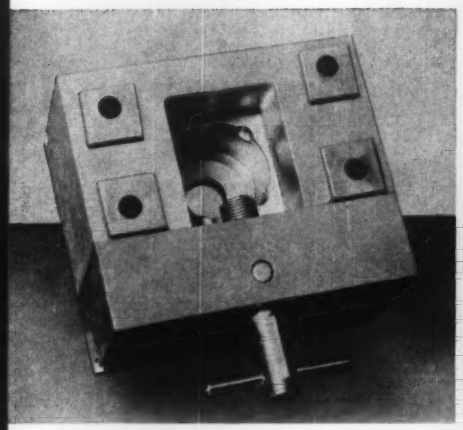
Molds for materials requiring high-molding pressures are made from a single block of prehardened tool steel. The hardness of this metal makes machining difficult, and this is further complicated by the necessity of working in tight corners. A lot of skilled handwork is required. The cost of prehardened tool steel is high, and a high-pressure mold is usually made at least 6 in. larger in all dimensions to

But conventional molds may be preferable when:

- **number of parts to be produced is large.** Then the cost per piece is not significantly increased by the higher cost of the heavier, more complex mold. (However, built-up molds have been used for production runs of over 150,000 pieces with no sign of failure.)
- **parts require extreme side wall taper.** Solid molds may be required to withstand the outward thrust which tends to open up or spread a built-up mold.
- **required radii rule out built-up molds.** If the design cannot be changed, solid molds are recommended.
- **parting lines are objectionable.** Appearance in consumer items may demand absolutely smooth finishes.
- **design of the mold is so simple that shaping is no problem.** In this case, the cost of the mold can be reduced by using less costly materials ordinarily used in built-up mold construction.



Aircraft terminal board (bottom), made in low-pressure mold, is more easily redesigned than one made in a more expensive high-pressure mold. It has better strength and dielectric properties and is 60 per cent lighter than previously used part machined from solid laminate (top).



withstand the great molding force and to provide room for steam heating cores.

High expenses can often be eliminated if the designer calls for low-pressure molding. Built-up molds are made of relatively inexpensive and readily available materials such as mild steel, high-density aluminum jig and fixture plate, and flat-ground stock. Hardened drill rod, dowels, and bushings—also standard items—can be used to assemble the details of the mold. Sidewalls, pins, etc., are incorporated into the finished mold by either welding or bolting—both simple techniques. Since the mold maker is working with only a flat, shallow piece of stock at any one time, machining uses normal techniques and equipment. Parts can be readily unbolted and removed, so that repairs are fast and inexpensive.

Build-Up Technique Aids New Product Design

The built-up mold is especially valuable to the designer of a new product, who finds modification is almost inevitable. The mold can be disassembled and changed to conform to the redesign without difficulty.

Production flexibility is another advantage. Since most built-up molds are electrically heated, it is relatively simple to add more cavities as production increases. Addition of cavities is considerably more expensive with steam heated high pressure molds, where steam-tight seals between sections or complete replacement of the original mold would be required.

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1. LINCOLN
2. MERCURY
3. EDSEL
4. FORD
5. THUNDERBIRD

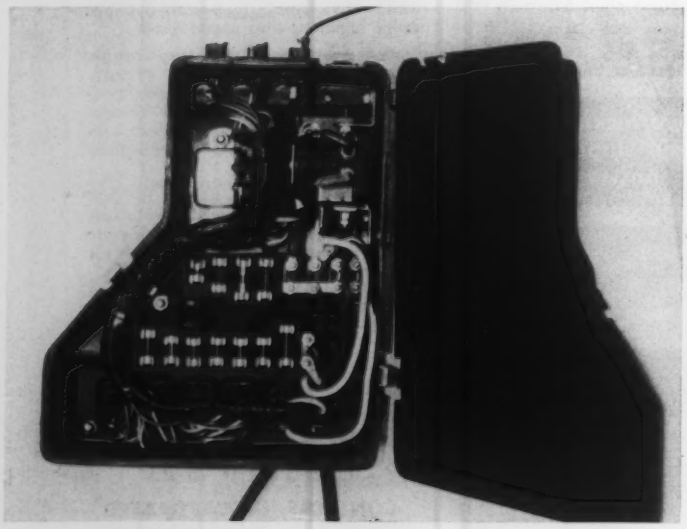
'60 Engines

Make and Model	Bore & Stroke (in.)	Displacement (cu. in.)	Compression Ratio	Power, max (bph)	Torque, max (lb-ft)	Carburetion
LINCOLN	4.30 x 3.70	430	10:1	315 @ 4100	465 @ 2200	2b
T-BIRD						
Standard	4.00 x 3.50	352	9.6:1	300 @ 4600	381 @ 2800	4b
Optional	4.30 x 3.70	430	10.1:1	350 @ 4600	490 @ 2800	4b
MERCURY						
Monterey	3.80 x 3.44	312	8.9:1	205 @ 4000	328 @ 2100	2b
Montclair	4.30 x 3.70	430	10:1	310 @ 4100	460 @ 2200	2b
Optional	4.30 x 3.30	383	8.5:1	280 @ 4200	405 @ 2200	2b
EDSEL						
Standard	3.75 x 3.30	292	8.8:1	185 @ 4200	292 @ 2200	2b
Optional	4.00 x 3.50	352	9.6:1	300 @ 4600	381 @ 2800	4b
FORD						
Standard	3.75 x 3.30	292	8.8:1	185 @ 4200	292 @ 2200	2b
Optional	4.00 x 3.50	352	8.9:1	235 @ 4400	350 @ 2400	2b
	4.00 x 3.50	352	9.6:1	300 @ 4600	381 @ 2800	4b
FORD, EDSEL						
Six cylinder	3.62 x 3.60	223	8.4:1	145 @ 4000	206 @ 2000	1b

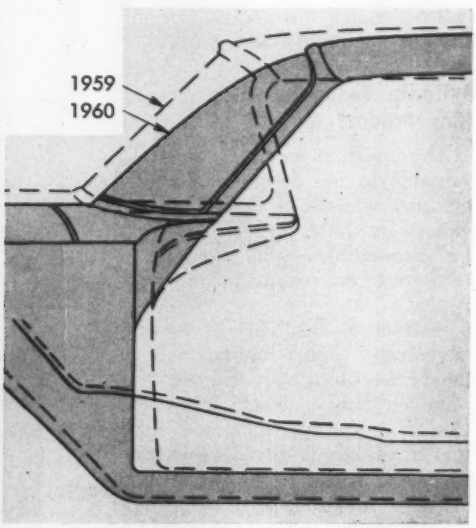
The survey of new cars continues in this issue with a rundown of the new mechanical features incorporated in Ford's '60 line-up. Chrysler cars and those of the independents will be covered in the next issue.

On the overall scene, small cars continue to grab the limelight. The big issue now, of course, is whether the public was anxiously waiting for true economy in a car, or whether most people were looking for racy styling and snappy performance in a smaller package.

Several marketing experts are already making cynical predictions on the basis of initial buyer reaction.

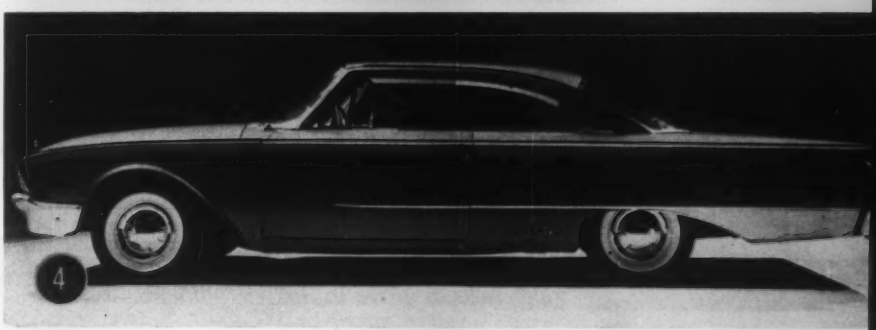


Lincoln's fuse box:
Centralizing the circuits.



Edsel's entry:
Amputating the dogleg.

the '60s take the road



They say the same old prestige factor that Detroit has lived with for years is beginning to overtake the small car, i.e., a man just doesn't like to see his neighbor behind the wheel of a bigger, racier, and more expensive "economy" car than his. If this is true, we may see *economy* versions of the present models in a very few years.

Lincoln

Lincoln's rear suspension is all new this year, with heavier and more rugged components. Shock absorbers, front and rear, have been increased from 1 to 1⅝ in. in diameter.

Power rating of the big 430 cu in. engine is down from 350 to 315 hp. Largely responsible is a new two-barrel carburetor in place of last year's four-barrel unit.

The car's electrical system is simplified, particularly in the engine compartment, by the mounting of all fuses and circuit breakers in a central "power box."

Edsel

A big face lift, accompanied by significant dimensional changes, gives Edsel new qualities in appearance and handling. Overall length of the car has been increased 5.5 in., while front and rear treads have been increased 2 and 3.6 in., respectively. The frame is 11.8 in. longer and about 2.5 in. wider. The result, of course, is better riding, handling, and considerably more passenger room.

'60 Sizes

Make and Model*	Wheelbase (in.)	Length (in.)	Width (in.)	Height† (in.)
LINCOLN	131	227.2	80.3	56.7
T-BIRD	113	205.3	77	52.4
MERCURY	126	219.2	81.5	56
EDSEL	120	216.4	81.5	55
FORD	119	213.7	81.5	55

*Four-door sedan (except T-Bird). †With full design load.

Edsel's face lift has resulted in at least one improvement that warrants duplication by other automakers: The lower corner of the windshield has been shoved forward 10 in. and the dogleg, a natural obstacle to getting in or out of a car, has been eliminated.

Mercury

According to Mercury's design team, the primary engineering effort on this year's model was directed toward noise and vibration reduction. The result: "Complete isolation of the car's body from the run-

ning gear." Absorbing materials, deadeners, barriers, and reflectors are used profusely. In addition, all mechanical components — windshield-wiper motor, heater-blower motor, etc.—have been moved from the passenger compartment to the engine side of the firewall.

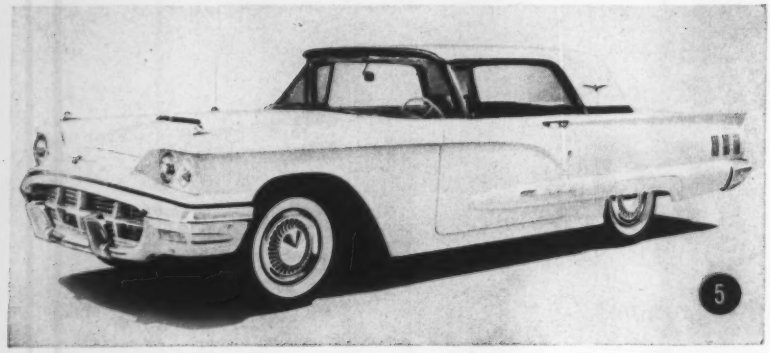
Mercury's electrical system has also been refined. Printed circuits are used for instrument-cluster wiring, and non-recycling circuit breakers replace many of last year's fuses.

Performance of the 430 cu in. engine has been cut somewhat by the use of a two-barrel carburetor, but car performance is not compromised because rear axle ratios are changed accordingly.

Thunderbird

Two optional items—a foreign-type sun roof and the most powerful engine in the Ford family—represent Thunderbird' major change-over to '60. The sliding roof is a 19 by 34-in. steel panel which slides on aluminum guide rails. A system of channels and drain tubes prevents leakage into the passenger compartment. Air is deflected over the opened panel by a deflector on the windshield molding. The overall effect: Quick ventilation of the passenger compartment — particularly noticeable after the car has been parked in the sun on a hot day.

Thunderbird's optional 350-hp engine is Lincoln's powerplant with a four-barrel carburetor.



Ford

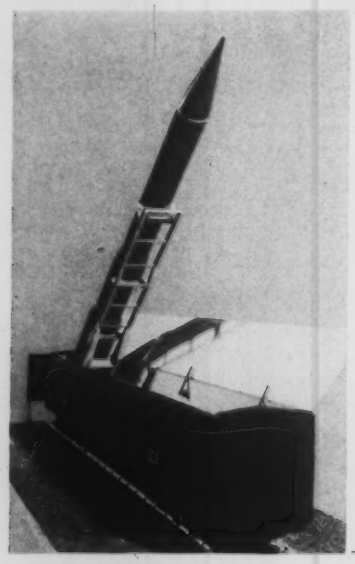
Ford, also, is heavily restyled with substantial changes in important dimensions. The new Ford frame, like Edsel's, is almost 1 ft longer and averages about 3 in. wider than last year's. Rear tread has been increased 3.6 in.; front tread, 2 in. for a big improvement in stability.

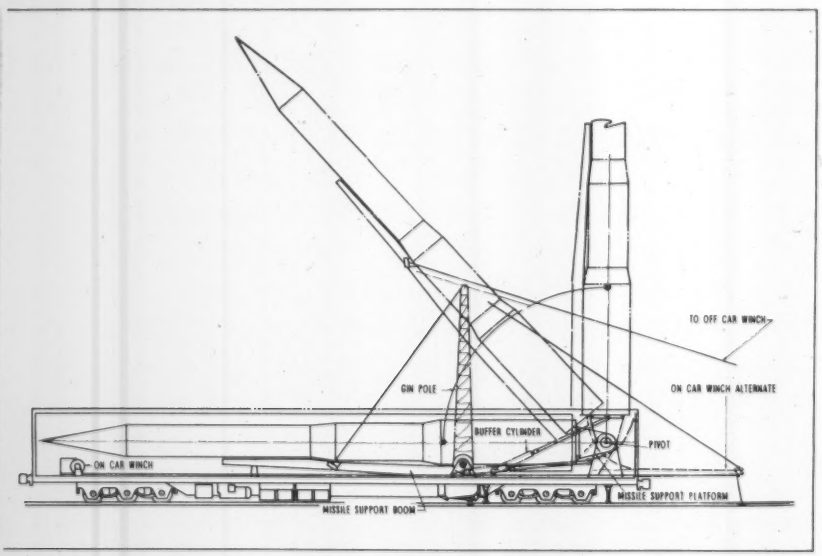
Rear suspension is completely revamped. New four-leaf springs are 5 in. longer and 0.5 in. wider than last year's. The axle is mounted well forward of spring center to kill rear-end squat during acceleration.

While Mercury's designers this year were busily moving all noise-making components out of the passenger compartment, Ford's designers cleaned up the engine compartment by moving the windshield-wiper motor and various heater components back inside.

Engine specifications are largely unchanged, although Ford will use a new cross-flow radiator like that on the Thunderbird.

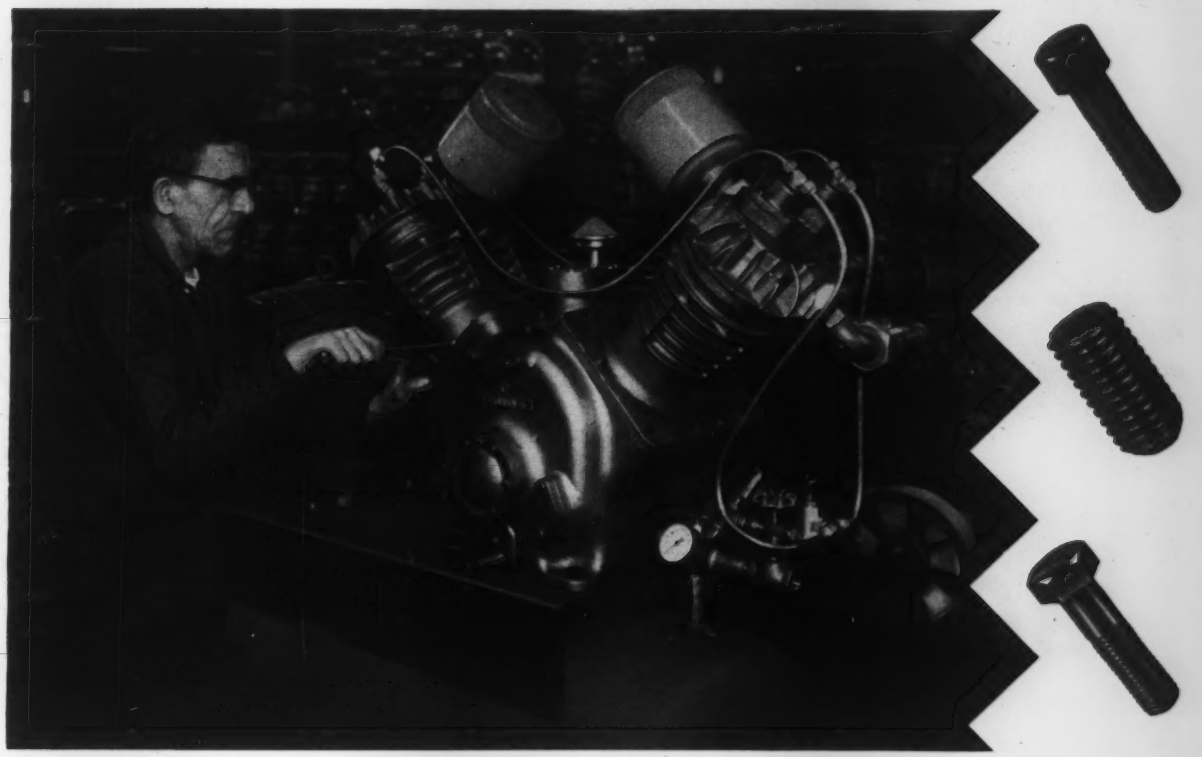
AMF Shows First RR Missile Launcher Model





To escape enemy detection, portable missile launcher closes up to look like an ordinary box car. Before countdown, the top opens and the missile is elevated to firing position by a cable-and-winch system. ACF Industries Inc. and American Machine & Foundry Co. displayed the model for the first time at the Air Force Association's 1959 Aerospace Panorama, Miami Beach, Fla. The launcher could handle ICBM's as well as IRBM's.

IT PAYS TO STANDARDIZE ON STANSCREW



Stanscrew provides faster service, adds safety for BRUNNER SINCE 1906 compressors

The fasteners this man is tightening must be really dependable. Dunham-Bush, therefore, maximizes the safety margin for its Brunner line by standardizing on Stanscrew heat-treated cap screws for all critical applications.

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STANDARD SCREW COMPANY 2701 Washington Boulevard, Bellwood, Illinois

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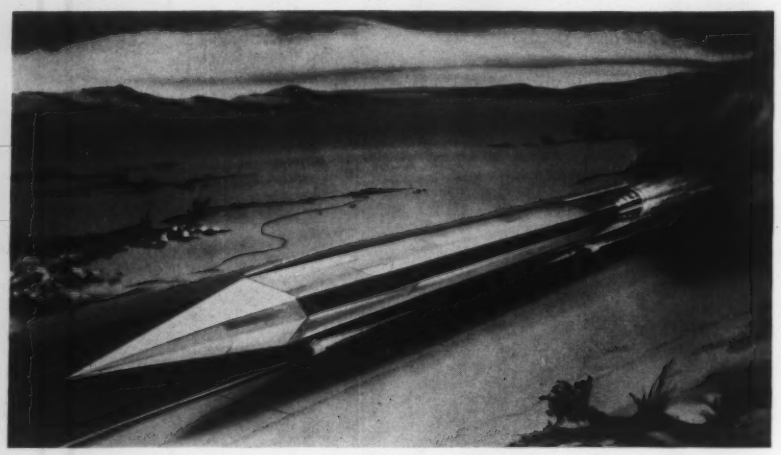
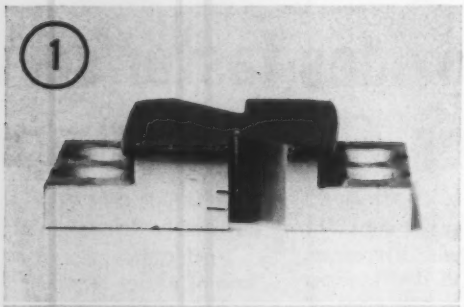
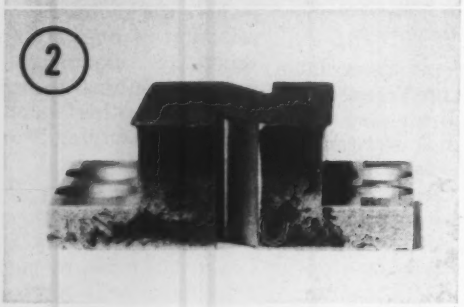
Rocket sleds are supported and guided on their short but violent runs by metal slippers that wear out at an alarming rate. Navy and Air Force researchers are concerned about what happens to them during an . . .

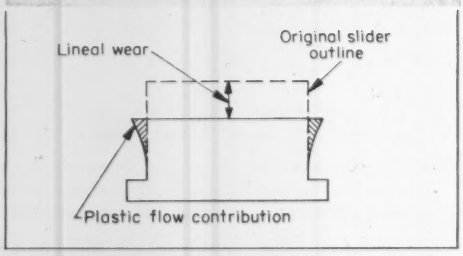


Sketch courtesy of Rocketdyne Div. North American Aviation.

1800 mph skid







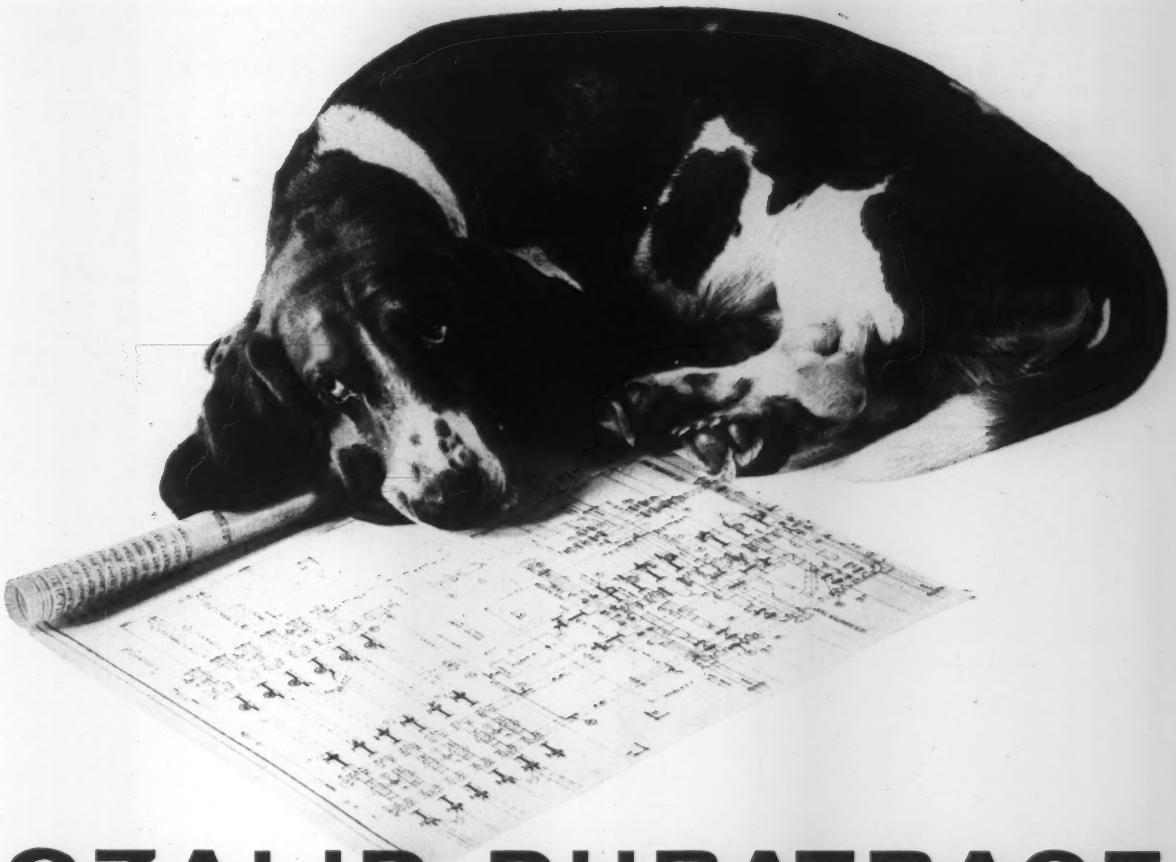
Dimensional change in steel slider (1) due to plastic flow was about 15 per cent of total observed change. Molybdenum slider **(2)** had less wear and showed plastic-flow contributed as much as 50 per cent to dimensional change on the comparatively small standard slider. Since plastic flow reduces sharply as area of a molybdenum slider grows, researchers feel it is not a significant factor in slipper design.

HIGH SPEED metal-to-metal friction is being resolved into workable design formulas and parameters through research under way at Naval Ordnance Test Station and Air Force Missile Development Center (NOTS and AFMDC). Under contract to the two military branches involved, Stanford Research Institute is studying action of high-speed rocket skids and has come up with materials and coatings that better withstand the punishment of supersonic sliding.

Chief contribution to wear during high-speed friction is melting of the slipper metal that occurs when the interface temperature climbs. The slipper rides on a thin film of its own molten metal, contributing to the film as it goes. This kind of wear by ablation, increasing as the 3/2 power of applied load, showed very little relation to speed in NOTS tests run in the neighborhood of 1200 fps. AFMDC tests, run at speeds up to twice as fast, showed a possible velocity effect on type 304 stainless steel. Researchers think these results may be due to the inertia of the large unsprung mass of the shoe.

On stainless-steel sliders, less than 15 per cent of the dimensional change was due to plastic flow. Although molybdenum sliders showed more (up to 40 per cent of linear change), NOTS researchers feel that plastic flow is not an important consideration in slipper design.

Molybdenum was found to be su-



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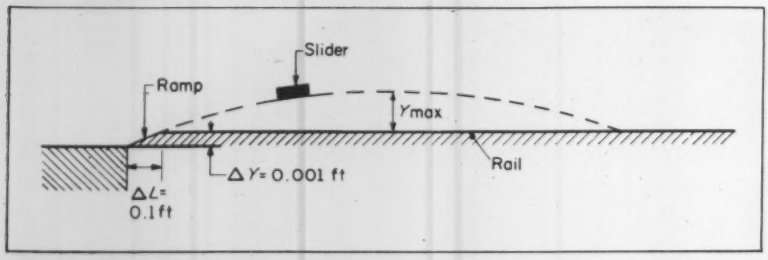
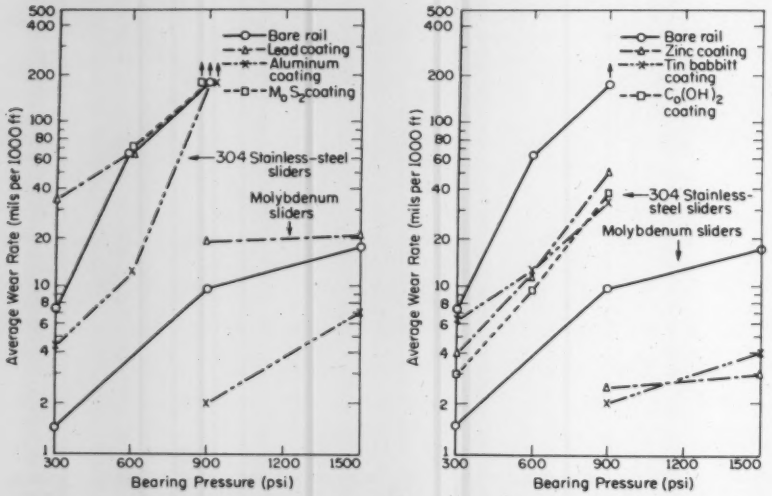


Using this hypothetical bump, researchers computed vertical accelerations due to track irregularities, found them much higher than anticipated. Irregularities consistent with the idealized ramp were found on the test tracks.



Plots show the significantly lower wear rates and higher possible bearing pressure for molybdenum under all test conditions. Lead performed poorly as a coating since it actually increased wear rate and damaged shoes and track besides. Zinc and calcium hydroxide made satisfactory coatings. Sled speed was 2500 ft per sec during these AFMDC tests.

perior to other materials tested as a slider on the tracks. However, its extreme brittleness keeps it from being immediately adopted as standard slipper material. AFMDC reports 30 per cent breakage in molybdenum test samples. Stanford Metallurgical Lab reports it is presently looking for more ductile molybdenum forms to offset this problem. Meanwhile, tests show that vanadium is nearly as good and much less brittle.

Rail coating was studied at AFMDC—both metal and nonmetal. Zinc was the outstanding metal coating among four tested, with lead getting the booby prize. Not only did slippers dig into the soft lead to cause more friction, but flying bits of molten lead turned out to be abrasive to the slipper and shoe. Among nonmetallic coatings, calcium hydroxide, in the form of whitewash sprayed onto the rails, took top honors. Molybdenum disulfide performed poorly, and researchers speculate that bond to rail was poor—the chemical was blasted off the track before the slider hit it. One slipper material—vanadium—and two rail coatings—zinc and calcium hydroxide—were recommended by the researchers as a result of the study, along with the suggestion that further investigation be made of the possibility of raising molybdenum ductility.

Surprise finding during the program was the magnitude of vertical inertial forces present during a high-speed run on supposedly smooth track. Where theorists had allowed for a possibility of 10 g, sheared pins and failed testing components proved the presence of vertical forces on the order of 10,000 g! Somewhat tardily, a stylized track irregularity was postulated consisting of a ramp with an upward slope of 0.001; accelerations of 10,000 g were justified mathematically. Irregularities corresponding to such a ramp were found on the tracks where the programs were run.

The Test Equipment . . .

Tracks

Both Navy and Air Force facilities have dual-rail tracks made of 171 lb per yd crane rail. Foundations are H-shaped concrete beams, half buried in the ground. The upper half of the beam makes a continuous trough for water braking.

At China Lake, Calif., NOTS track, called SNORT (Supersonic Naval Ordnance Research Track), is 21,550 ft long, and is made of 50-ft lengths of rail. Joints are butt-milled and doweled. Mill scale is not removed from the track. Track is laid at standard railroad gage (4 ft 8½ in. between rails).

The newly completed AFMDC track at Holloman AFB, New Mexico, is 35,000 ft long, although the last 5000 ft were not finished at the beginning of the testing program. Rails were stretched uniformly before anchoring so they are in tension below 120 F. Joints are welded and ground; mill scale is removed. Track is laid at 7-ft gage to make a water trough 6 ft wide by 1½ ft deep.

Pusher Sleds

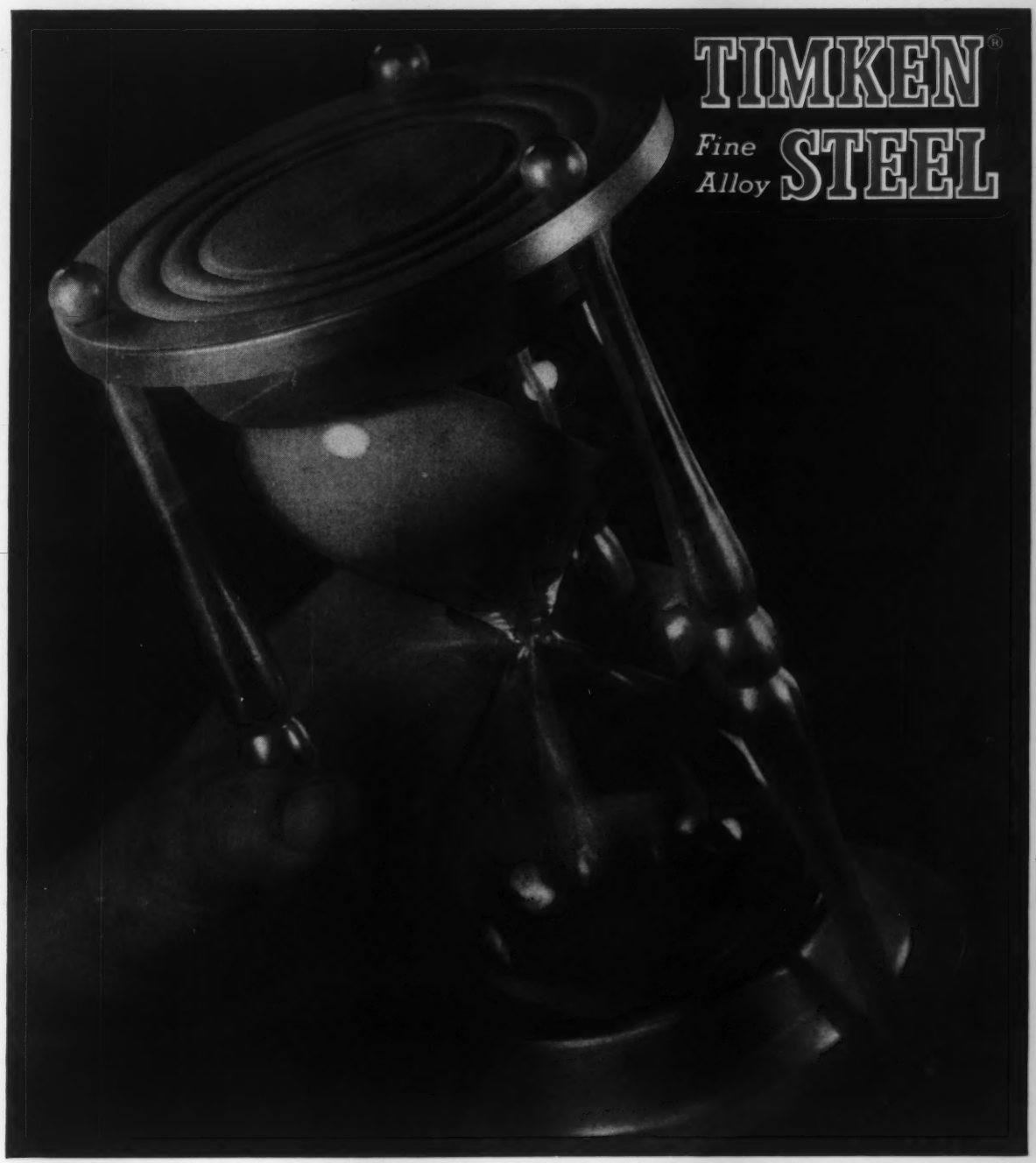
NOTS specimens were pushed up to 1250 fps by a modified dual-rail Bomarc sled. AFMDC designed a special lightweight monorail sled (Viper I), that attained speeds up to about 2500 fps. Air brakes and cotton straps stopped it within 20,000 ft. Both sleds carried FM/FM telemetering equipment and a tape recorder.

Shoes

Specimens were carried in especially designed shoes. These included a means of mounting the specimen, controlling the load applied to it, and a means for dropping the specimen on the track at the proper time (i.e., as the shoe was passing the chosen test section). An ingenious powder-charged guillotine sheared a retaining pin to do this job.

Specimens

Specimen sliders were 1 by 2-in. blocks of the chosen material. AFMDC tested sliders of type 304 stainless, SAE 4140 steel, molybdenum, and vanadium. NOTS used in addition sliders made of copper, tungsten, and titanium-molybdenum alloy.



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Cylinder head gasket is the VIC-2-FOLD metal-encased asbestos construction. It provides maximum sealing strength, permits close thickness control. Steel bottom layer, formed upward in cylinder openings, gives best burnout resistance. Copper top layer, formed down in other openings, gives best corrosion resistance.

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K3

Case-O-Matic clutch shaft and power take-off shaft are sealed with Victor K3 Victoprene oil seal. This narrow-width design for compact housing provides controlled lip pressure sealing; coating of synthetic rubber. Also seals at toe and O.D.

K4

Transmission power output shaft is dual-lip sealed with K4 Victoprene oil seal. Inner lip retains lubricant; outer lip excludes dirt. Victoprene on O.D. and toe also seals housing.

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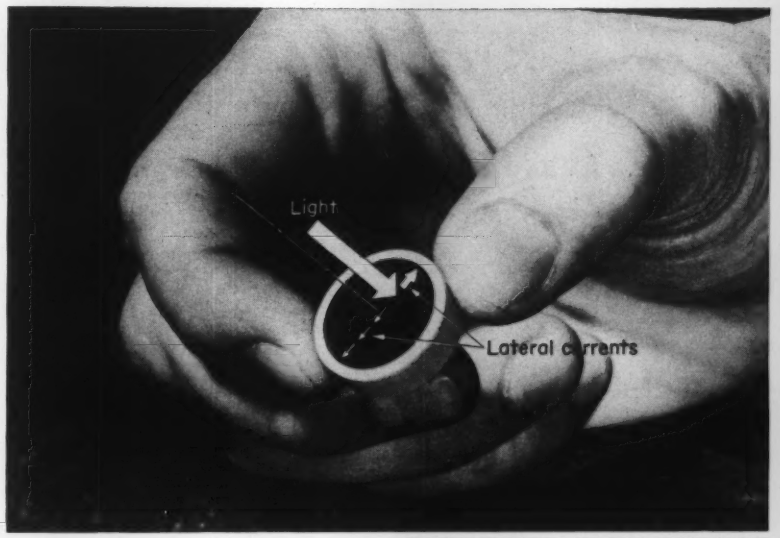
Sealing Products *Exclusively*

50th ANNIVERSARY

Your authoritative guides to sealing specifications—Victor Gasket and Oil Seal Engineering Catalogs. Write for free copies.

GASKETS • OIL SEALS • PACKINGS • MECHANICAL SEALS



Target Tracker

Semiconductor wafer the size of a nickel tracks aircraft and missiles without help from complicated mechanical apparatus. Infrared or light focused by a lens system (right) generates lateral photovoltages when it strikes the wafer (p-n semiconductor junction). If the beam strikes the center, voltages cancel out. Otherwise, net voltage is proportional to the distance of the beam from center, and polarity depends on which side of center is hit. The unit, developed by Electro-Optical Systems Inc., Pasadena, Calif., resolves angular position of the beam (the target) along either one or two axes. Signals can be fed into an X-Y plotter.

Famed Fighter Engine Powers Pipeline Pump

J57 Competes Successfully With Heavy Industrial Turbines

MT. VERNON, OHIO — America's most successful jet engine of the '50's, P&WA's J57, is now finding civilian jobs against rugged competition from industrial gas turbines—and beating them at their own game. At first glance it may seem uneconomical to pit the lightweight, short-lived aircraft engine against heavy industrial gas turbines built for long life in ground service, but experts point out that the J57's short life expectancy is due to short flights and high-powered take offs. "Cruising" at operating speed without stops and starts, it will run six to eight times as long as in aircraft between overhauls.

Hot jet from the stationary J57 will turn a free turbine in a setup developed by Cooper-Bessemer Corp., Mt. Vernon, Ohio. The turbine drives a pipeline gas pump. For added simplicity the turbojet will run on gas from the same pipeline.

Advantages of the J57 over the heavyweight industrial turbines are:

- An engine already in mass production—development costs are largely written off.
- High thermal efficiency—regenerators are not used.
- Efficient overhaul—aircraft-package techniques allow removing one lightweight engine and installing another, so the pump continues to run while the engine is getting expert factory overhaul.
- Power—10,500 hp from a 4000-lb engine.

PLATE-TYPE
RHEOSTATS

LESS CONTACT WEAR WITH G-E RHEOSTATS

Less contact wear means longer rheostat operating life, and General Electric rheostats feature special wear-resistant contact segments. The moving contact rides on these segments—not on the resistance element. For full details on G-E long-life plate rheostats, follow reader service instructions below. General Electric Company, Roanoke, Virginia. 784-22

Progress Is Our Most Important Product

GENERAL ELECTRIC

Circle 420 on Page 19

Circle 421 on Page 19→

Get better protection...more reliable

...WITH GENERAL ELECTRIC

operation for your product

TRI 55 CLAD ENCLOSED MOTORS

HERE'S WHY:

External Features: Moisture-resistant sealing compound is applied on carefully machined rabbets to assure better protection against moisture and dust. Corrosion-resistant, non-sparking fan on all enclosed fan-cooled Tri/Clad '55' motors resists action of the strongest acids and alkalis. Jet action cools motor effectively and efficiently for long-life operation.

Lead connections are protected from contact with moisture and dirt by a cork-neoprene gasket between halves of the easy-access conduit box.

Further, a new lead positioner gasket between conduit box and frame is impervious to cutting fluids—protects internal parts effectively.

Internal Features: Mylar* polyester film insulation and Formex† magnet wire provide greater moisture and heat-aging protection. Water-resistant stator coating also guards against failure due to moisture. And G.E.'s advanced bearing system gives years more service.

General Electric offers you the most complete line of enclosed motors in the industry, including standard enclosed, severe-duty (for highly corrosive atmospheres), and explosion-proof motors.

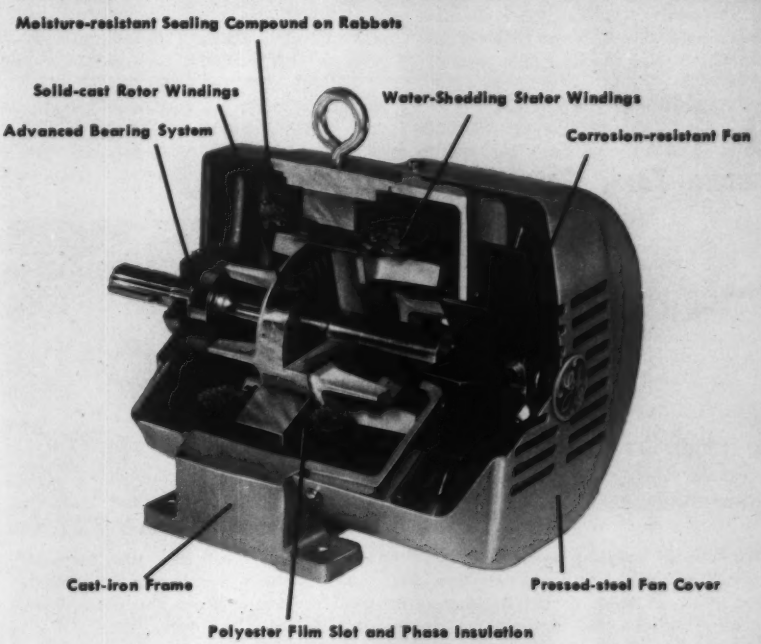
CONTACT your nearest G-E Apparatus Sales Office now for *personal proof* on why G-E Tri/Clad '55' enclosed motors can do a better job for your applications. And ask for a free copy of these descriptive motor bulletins: 1-5 hp—GEA-6240, GEA-5980, and GEA-6341; 7½-125 hp—GEA-6602. Or write for them to Section 840-20, General Electric Co., Schenectady 5, New York.

*Registered Trade-mark of DuPont Co.

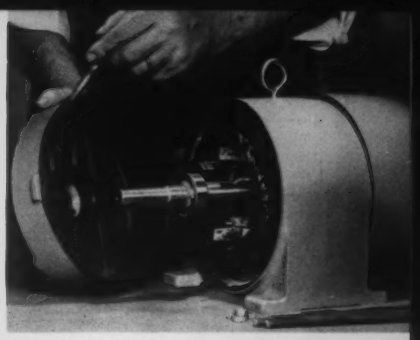
†Registered Trade-mark of General Electric Co.

GENERAL ELECTRIC

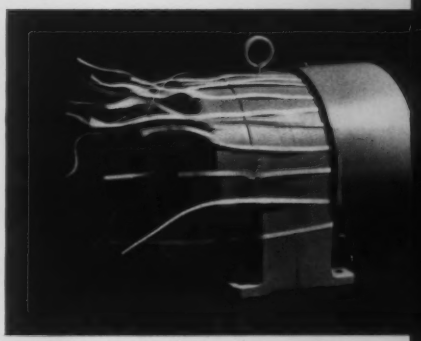
COMPARE THESE TRI CLAD FEATURES



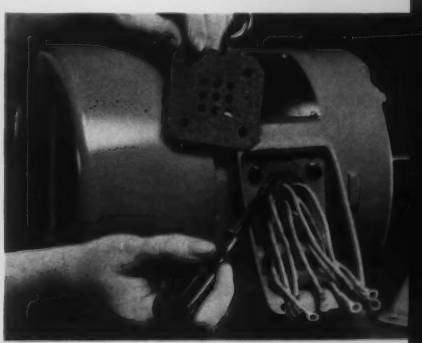
Standard enclosed Tri/Clad '55' motor



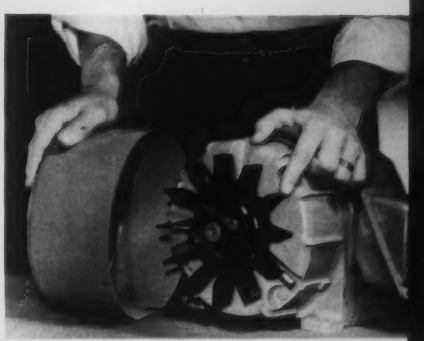
Water-resistant Rabbets protect against moisture, dirt, and abrasive dust for longer life.



Efficient Jet Cooling System spreads a smooth blanket of air over the entire motor frame.



New Lead Positioner and gasket saves connection time; is impervious to cutting liquids.



Non-sparking Fan effectively cools the motor—resists action of strongest acids and alkalis.

Vibration can't loosen Loctite-treated fasteners

The HOMELITE six-horsepower chain saw weighs only 19 pounds. So much power per pound requires maximum resistance to vibration in the fasteners holding parts together.

LOCTITE, the liquid lock washer, locks all critical fasteners on this gasoline-driven chain saw . . . providing dependable service in rugged field use.

LOCTITE Sealant is a liquid which hardens between metal parts to form a bond with greater holding power than any mechanical locking device. The added holding power of LOCTITE-treated fasteners allows Homelite to use reduced tightening torques and thus avoid stripping threads in the aluminum castings.

While adding to product reliability, LOCTITE provides substantial cost savings. At Homelite, the 27 different size fasteners required in assembling the chain saws are treated with LOCTITE by tumbling in plastic bags. Treated screws store for days . . . lock only when assembled.

There's a Loctite application method suited to all production requirements. If your product faces shock and vibration in use, you can eliminate breakdowns due to loose threaded fasteners . . . cut service cost and customer complaints . . . by using Loctite. Write for literature and free sample.

LOCTITE® SEALANT
AMERICAN SEALANTS COMPANY
111 Woodbine St., Hartford 6, Conn.
In Canada: J. S. Parkes & Co., Ltd., Montreal

Circle 422 on Page 19

How Much "Boom" Breaks a Windowpane?

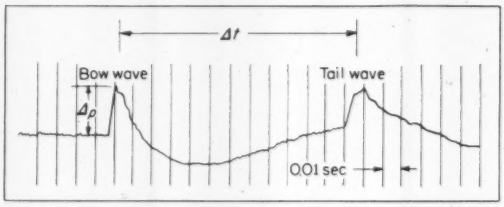
NASA Checks Strength Of Annoying Sonic Booms

LANGLEY FIELD, VA. — NASA has been checking on the pattern of those devastating sonic booms that plague civilians in the wake of supersonic aircraft. Findings show two factors determine the occurrence of the boom: Suddenness of the change in pressure, and difference in pressure across the shock wave. A pulse of more than 1 lb per sq ft, arriving suddenly, sounds like a thunderclap. Pressure changes less than 0.5 lb/sq ft are usually not noticed.

Test planes, flying from 25,000 to 45,000 ft high at speeds from Mach 1.13 to Mach 1.4, generated pressure pulses that were felt by residents in the area of the test. One store window was broken. Highest measured change in pressure was 1.75 lb per sq ft, although it was estimated to be higher in the region of the broken window.

For each pass, two booms were recorded and usually felt or heard by observers; pulses corresponded to bow and tail waves of the plane. NASA also studied effects of wind and temperature in changing both direction and speed of sound propagation. In some cases, they say, the beam of sound may be bent so that it misses the ground altogether.

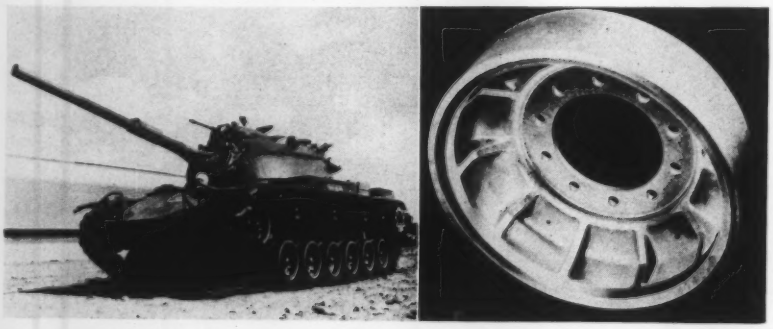
Two distinct peaks are recorded for a typical sonic boom. Usually observers were able to detect two sharp sounds. Plot shown is for first flight recorded in table.



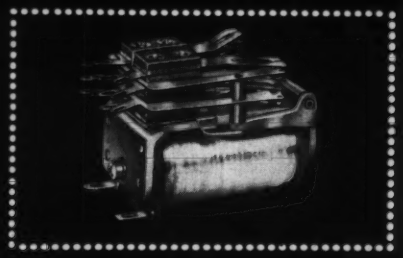
Shock Overpressures

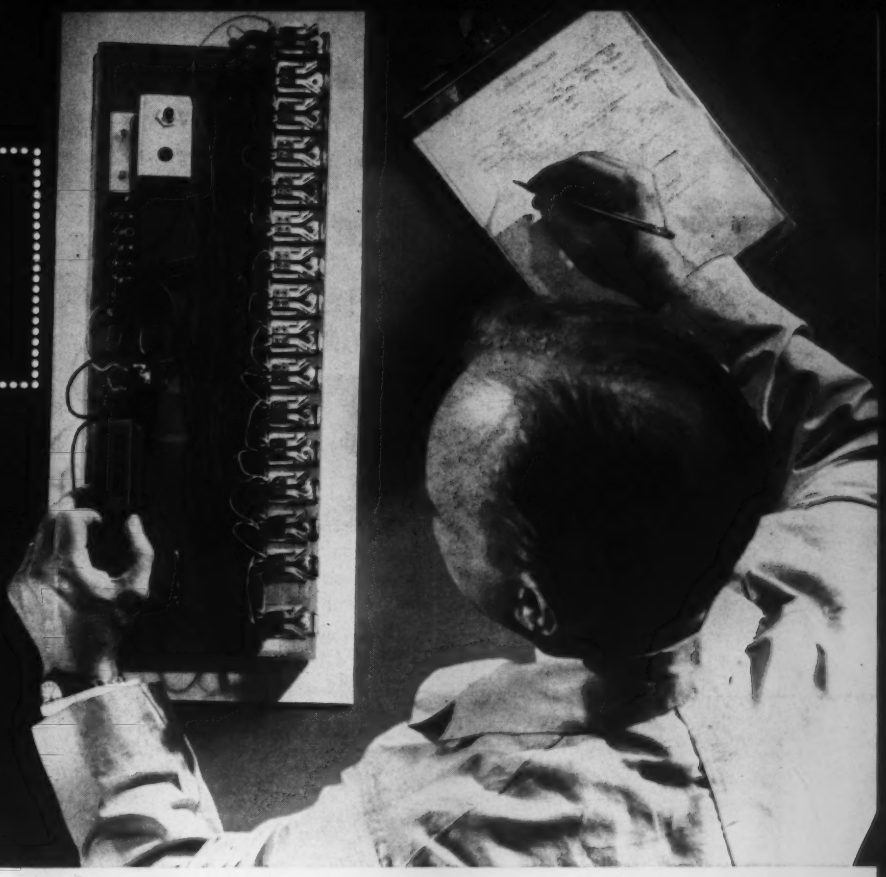
Altitude (ft)	Mach No.	Distance to Flight Path (mi)	Pressure Pulse (lb/sq ft)	Time Between Peaks (sec)
35,000	1.40	3.7	0.99	0.123
25,000	1.22	3.5	1.75	0.136
40,000	1.31	3.5	1.38	0.121
45,000	1.28	2.1	1.08	0.126
35,000	1.13	2.1	0.91	0.132

Battle Tank Gets Aluminum Wheels



One way of keeping down weight of the Army's new M-60 tank was to specify lightweight materials wherever possible. Consequently wheels will be made of aluminum. Forged at the Bridgeport Brass Co., Adrian, Mich., the road wheels contain built-in ribs (an integral part of the forging) for added strength and weigh about 80 lb each. Idler wheels weigh 13 lbs.





213,149,873
cycles

Test proves reliability of P&B's LS telephone type relay

These 16 LS relays, wired into a self-cycling chain, each operated 213,149,873 times before the test was discontinued. This test was made for a nationally prominent manufacturer and the certified results are available upon request.

Here is proof of the inherent reliability of P&B telephone type relays . . . and of the kind of performance you can expect when you specify them. LS relays are available with up to 20 springs (10 per stack) and are adaptable for printed circuit mounting.

Whenever multiple switching of loads up to 4 amperes is required, the LS can usually meet space, weight and—importantly—price considerations. Get full information today by calling or writing Zeke R. Smith, vice president, Engineering, or contact your nearest P&B representative.

LS ENGINEERING DATA

GENERAL:

Breakdown Voltage: 1,000 volts rms 60 cy. min. between all elements.
Ambient Temperature: —55° to +85° C.
Weight: 3 to 4 oz.
Dimensions: 1 5/32" W. x 2 3/8" L. x 1 1/2" H. (4 Form C)
Enclosures: Sealed or dust cover (W can) Sealed or dust cover, up to 6 Form C, single contacts (D can)
Mountings: Four #6-32 tapped holes 3/4" x 5/16" o.c. Other mountings available.

CONTACTS:

Arrangements: 20 springs (10 per stack) max.
Material: 1/16" dia. twin palladium. Other materials available for specific applications.
Load: 4 amps @ 115 volts 60 cy. resistive.

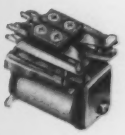
COIL:

Resistance: 55,000 ohms max.
Power: 65 mw DC per movable standard (50 mw possible); 3.5 watts max. at 25° C.
Voltage: Up to 200 volts DC.

TERMINALS:

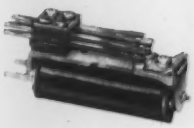
Contacts: Three #18 AWG wires.
Coil: Three #20 AWG wires.
Available with octal plug, taper tabs or printed circuit pins.

P&B STANDARD RELAYS ARE AVAILABLE AT YOUR LOCAL ELECTRONIC PARTS DISTRIBUTOR



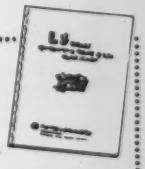
TS RELAY
Short coil relay is available in AC and DC versions. Long life construction. Can be supplied (DC) with up to 20 springs (10 per stack).

GS RELAY
Excellent sensitivity: 50 mw per movable arm minimum (DC). For applications requiring many switching elements in small space.



BS RELAY
Long coil provides high sensitivity (25 mw per movable arm) and room for slugs for pull-in delays (150 milliseconds max.) or drop-out delays (600 milliseconds max.).

FREE
LS DETERMINATION DATA
Send today for booklet containing certified results of recent test described above. Data includes test circuit, interim and final measurements.



POTTER & BRUMFIELD
DIVISION OF AMERICAN MACHINE & FOUNDRY COMPANY, PRINCETON, INDIANA
IN CANADA: POTTER & BRUMFIELD CANADA LTD., GUELPH, ONTARIO

Circle 423 on Page 19

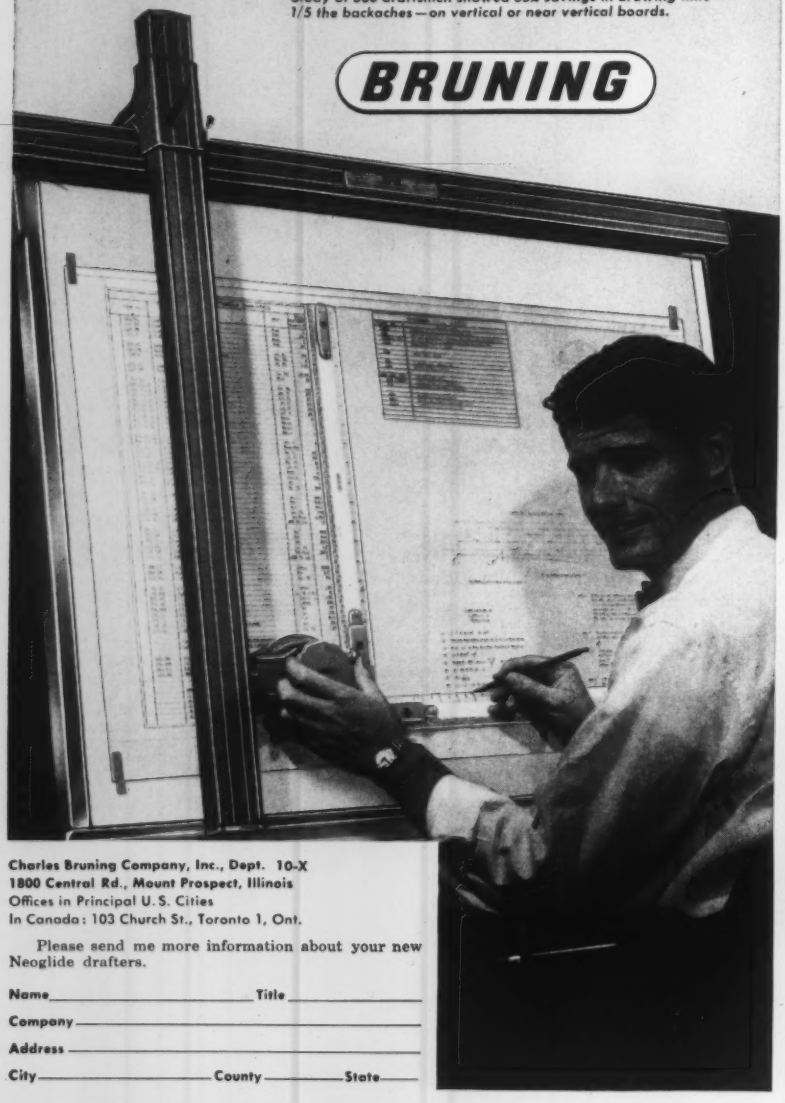
now!

draftsmen can lead a more upright life and do faster, better work!

Bruning's all-new Neoglide drafters literally help draftsmen *straighten up* and do faster, better work.* They provide complete maneuverability on any board *at any angle* without adjustment! Reinforced U-beam construction assures rigidity, strength, and accuracy. Resistance-free movement of vertical beam and hidden counterweight provide fast "floating" action. Touch-control protractor head gives automatic, pin-point angle selection. Mail coupon, now, for *straight* facts about Neoglide savings.

*Study of 300 draftsmen showed 35% savings in drawing time—1/5 the backaches—on vertical or near vertical boards.

BRUNING



Charles Bruning Company, Inc., Dept. 10-X
1800 Central Rd., Mount Prospect, Illinois
Offices in Principal U. S. Cities
In Canada: 103 Church St., Toronto 1, Ont.

Please send me more information about your new Neoglide drafters.

Name_____ Title _____

Company _____

Address _____

City _____ County _____ State _____

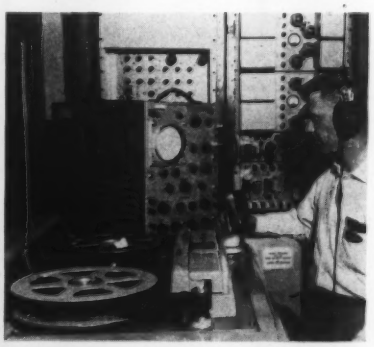
Revolving Head Tape Recorder Picks Up Radar Signals

Tape-to-Head Velocity Is High Although Tape Speed Is Low

REDWOOD CITY, CALIF.—Newest use for a tape recorder is recording radar signals picked up from a missile in flight. A special revolving head assembly, developed by Ampex Corp., modifies a standard Videotape Recorder for the job.

Even though radar signals are first converted to a lower frequency (they are in a frequency range too high to be directly recorded), the converted signals contain many high-frequency components beyond the range of standard recorders. Frequencies range from dc at the low end to 4 megacycles at the high end. Recording a 4-megacycle signal (using even the most precise recording heads) would require a tape speed of about 200 ips. Ampex solved the problem by developing a special revolving head assembly. The 2-in. wide tape moves at only 15 ips past a rotating disc with four equally spaced magnetic heads. Because the head assembly is turning at 14,400 rpm, tape-to-head velocity approaches 1500 ips.

The machine aids missile data evaluation since various portions of the trajectory may be restudied without screening thousands of feet of film from optical systems. On a special "cue" channel of the tape, voiced comments can be added to facilitate finding certain sections for later reference.



Despite the electronic complexity of the Videotape Recorder, no specialized personnel are required to operate it. Actually, it operates about the same as most voice recorders. One reel holds 64 minutes' recording.

Metals Matters

New aluminum engines . . .
may have cast-iron cylinder liners included as inserts in the diecasting. Mechanical interlocks on the rough surface of centrifugally cast grey iron liner are formed when aluminum is pressed into undercut voids by diecasting pressure. The bond, called BMI (Bi-Metallic Interlock) by the developer, Doehler-Jarvis Div., National Lead Co., Toledo, Ohio, has been submitted for patent. BMI inserts may also be used for liners on aluminum brake shoes and wheels.

Exotic metals research . . .
will be conducted at a new center to be built at the E. I. du Pont de Nemours & Co. Inc. plant in Baltimore. The installation will have equipment to forge, extrude, roll, draw, and heat-treat refractory metals like niobium, tantalum, titanium, zirconium, and tungsten.

Gas plating of titanium . . .
has been patented by Commonwealth Engineering Co. of Ohio, Dayton, Ohio. A gaseous titanium compound is decomposed by exposure to a heated surface. The titanium precipitates out to form a dense plate. Since the process is done in an inert-gas atmosphere, hydrogen embrittlement is avoided.

Metal coating protects . . .
copper conductors from oxidizing when operating in the 600 to 1000 F temperature range. North American Aviation, Inc. finds a coating of 10 per cent by weight of nickel or stainless steel allows a conductivity as high as 90 per cent (IACS) in copper wire. Diffusion of copper into coating metal is a problem solved by using an inert boundary material.

Columbium alloy sheet . . .
for high-temperature aircraft and missile applications is the object of an applied research program starting at Crucible Steel Co., Pittsburgh, Pa., under contract from Wright Air Development Center. Columbium, which melts at 4475 F, promises the lightest structures of any metal at incandescent jet and missile temperatures. Objective will be flat rolled sheets with ultimate tensile strength of 100,000 psi and yield strength of 80,000 psi. Alloys are sought that have high strength properties in the range from 2000 to 2600 F. Crucible just completed a similar titanium rolling program, and WADC is also sponsoring one for beryllium.

by Design

BIJUR

AUTOMATICALLY ASSURES CUSTOMER SATISFACTION

the user of your machines

- Increases Productive Capacity
- Saves on Repair Bills
- Eliminates Costly Hand Oiling
- Reduces Downtime
- Lengthens Machine Life

WITH Bijur Automatic Lubrication as an integral part of your equipment, your customers benefit from continuous peak production. Plant after plant reports increased out-put and greatly reduced maintenance costs with Bijur-equipped machines. Costly downtime for lubricating by hand is eliminated. Every bearing is metered the proper quantity of oil at predetermined intervals. Work spoilage and bearing troubles caused by over-lubrication are avoided. Fire hazards are reduced. Personnel accidents are prevented.

Bijur gives you the opportunity to add customer satisfaction through improved machine performance.

More than a million Bijur-protected machines are in use. Hundreds of leading manufacturers standardize on Bijur as "built-in" components of their machines. Bijur emphasizes custom-engineering, and we will gladly cooperate in designing a system to meet the specific requirements of your machine.

Design Bijur into your machines now in production or in the planning stage. Write for literature and engineering information.

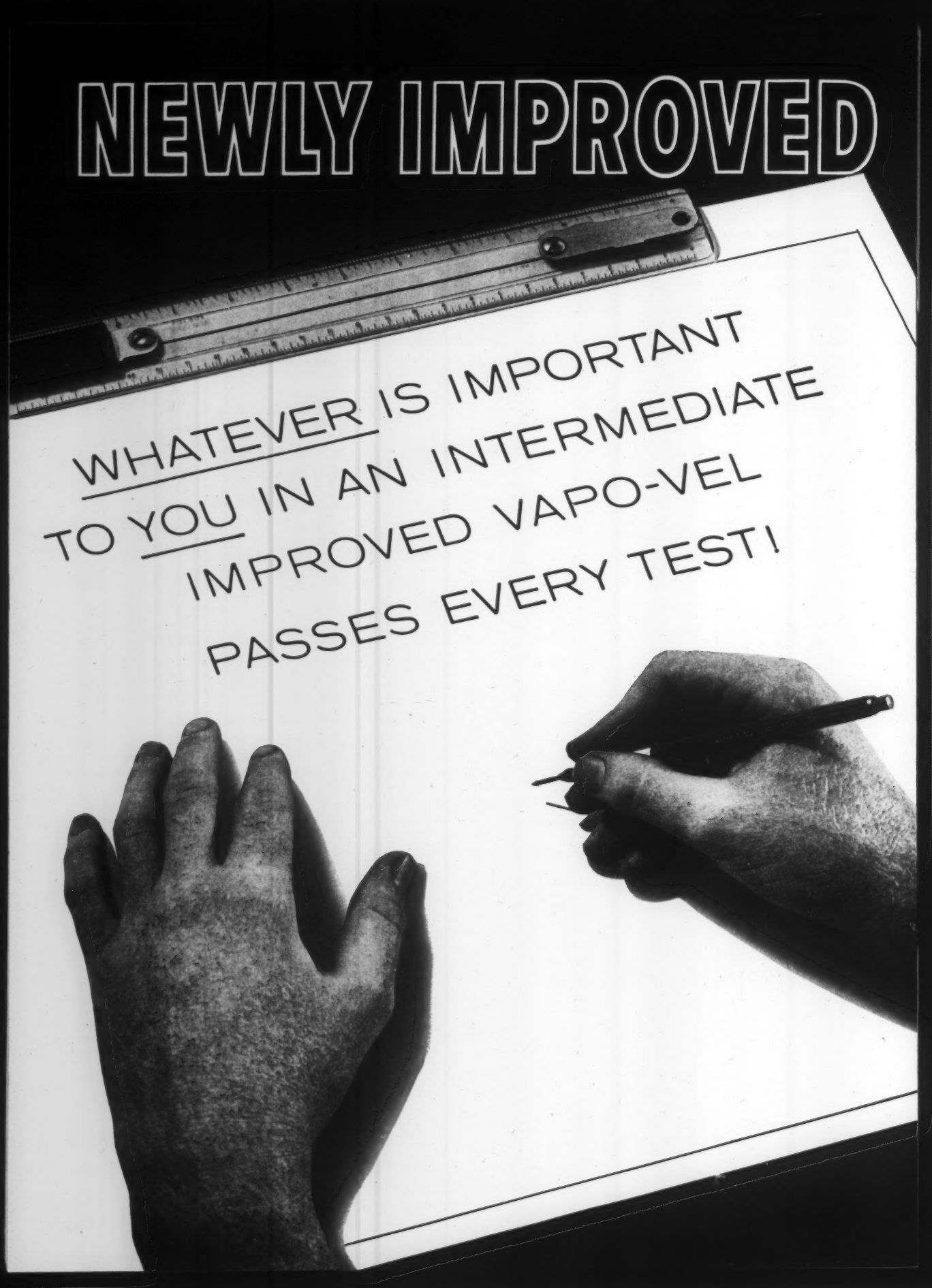
BIJUR AUTOMATIC LUBRICATORS—STANDARD EQUIPMENT IN MANY INDUSTRIES
Machine Tools • Business Machines • Printing Machinery • Textile Machinery • Food Product Machines • Bottling Machines • Packaging Machines • Sheet Metal Machines • Plastic Fabricating Machinery • Glass Products Machinery • Wood-Working Machinery • Industrial Sewing Machines • Special Process Equipment

2369A

BIJUR
LUBRICATING CORPORATION
Rochelle Park, New Jersey
Pioneers in Automatic Lubrication

Circle 425 on Page 19

NEWLY IMPROVED



POST VAPO-VEL

Here's a sepia intermediate that handles just like the best vellums

As a result of The Frederick Post Company's long and intensive research in intermediates and coating technology, there is now available a dramatically improved sepiatone vellum. POST Vapo-Vel (209) combines *every* important feature you've been looking for in a transparentized paper-base print—top drafting qualities, superior shelf-life and filing characteristics, and outstanding printback speed. An extra dividend: Vapo-Vel's cost per print is surprisingly economical compared to other types of intermediates.

To the man on the board, this newly improved Vapo-Vel is a real find. It has all the drawing and transparency features of a top-notch vellum, even that crisp vellum "feel." Vapo-Vel's easy-to-read dark brown image and outstanding transparency eliminate eyestrain in modification work on the back of reverse-reading prints. The surface takes pencil and ink without feathering. Pencil erasing characteristics of this strong 100% rag premium paper are truly outstanding, while eradication of print images is easily accomplished.

You check it! Whatever your special interest, test 209 Vapo-Vel ammonia process prints for factors most important in your own operations. Whatever your prime requirements may be, POST welcomes a comparative evaluation of diazo-type sepia papers for each and every one of these prime characteristics:

PASSES EVERY TEST!

Image Density—Visual
Drafting Qualities
Line Contrast
Readability thru Back
Eradication
Filing Characteristics
Image Density—Actinic Opacity (Printback)
Quality of Reprint
Image Bleed on Aging
Background Stability
Shelf-Life

Write today for your copy of the POST Vapo-Vel Kit. It contains sample prints to examine and test, a Print Characteristics Checklist, a Data Sheet and a copy of POST's popular booklet "11 Ways to Save Drafting Time." To keep up-to-date with the latest, just write Frederick Post Company, 3652 North Avondale Avenue, Chicago 18, Illinois.

FREDERICK POST COMPANY

CHICAGO 90 • ENGLEWOOD, N. J. • PITTSBURGH • DETROIT • MILWAUKEE • HOUSTON • SAN FRANCISCO • LOS ANGELES

Dealers in Principal Cities

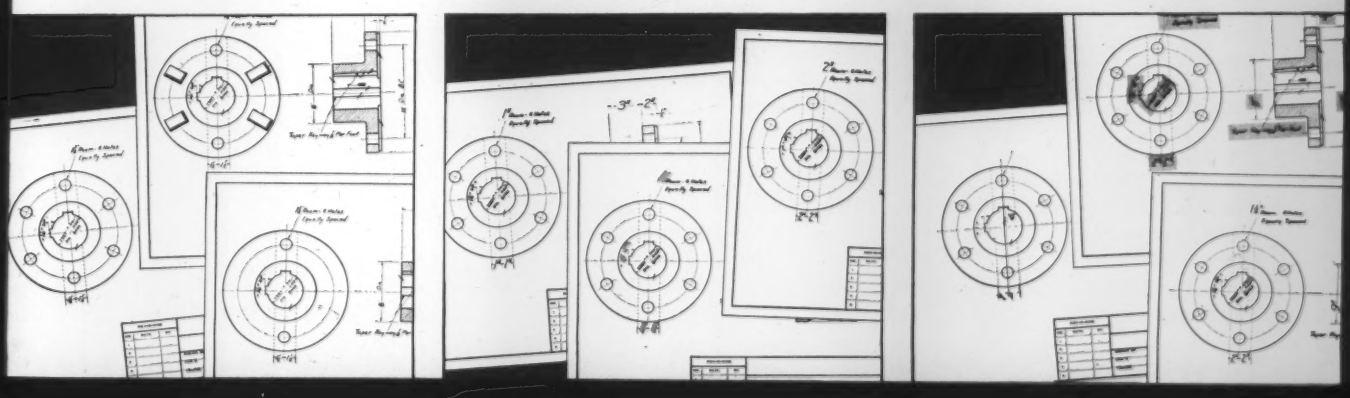
Circle 426 on Page 19

THESE SHORT CUTS WILL SAVE YOU TIME

From this . . . to this WITH NO ERASURES! When a large element in your original drawing requires modifications, simply *cut it out* of the first Vapo-Vel print. Draw in the changes on a second Vapo-Vel print . . . and you have a new master.

Make quick corrections over scattered areas. When small patches of your original drawing need alterations, make a Vapo-Vel intermediate. Then eliminate the unwanted lines with POST Eradicator Fluid and redraw.

Add variable data with transparent matte tape. It is often economical to maintain standard drawings without dimensions and other variables, adding this information on transparent matte tape, as needed to specific orders. A subsequent Vapo-Vel print then supplies the completed drawing.



Fasteners Institute Scheduled At University of Wisconsin

MADISON, WIS. — Program of the Fasteners Institute to be held Nov. 18-20 at the University of Wisconsin will include the following subjects: What fasteners are available; how to use fasteners properly; strength considerations; corrosion problems; choosing materials; assembly considerations; designing for hot and cold heading; 15 ways to save money in fasteners.

The program will be held at the university's Wisconsin Center Building. Further information is available from Richard A. McCormick, Institute Co-ordinator, 4016 Stadium, University of Wisconsin, Madison 6, Wis.

Meetings and Shows

Oct. 19-21—

American Institute of Electrical Engineers. 11th Annual Machine Tool Conference to be held at the Sheraton-Cleveland Hotel, Cleveland. Further information may be obtained from E. J. Loeffler, Warner & Swasey Co., 5701 Carnegie Ave., Cleveland 3, Ohio.

Oct. 21-23—

Society for Experimental Stress Analysis. Annual Meeting to be held at Hotel Pick-Fort Shelby, Detroit. Further information can be obtained from SESA headquarters, P. O. Box 168, Cambridge 39, Mass.

Oct. 22-23—

National Conference on Industrial Hydraulics to be held at Hotel Sherman, Chicago. Sponsors are Illinois Institute of Technology and its affiliate, Armour Research Foundation. Information can be obtained from R. D. Meade, Illinois Institute of Technology, 3300 Federal St., Chicago 16, Ill.

Oct. 25-28—

American Gear Manufacturers Association. Fall Meeting to be held at the Edgewater Beach Hotel, Chicago. Further information can be obtained from AGMA, 1 Thomas Circle, Washington 5, D. C.

Oct. 26-28—

Society of Automotive Engineers Inc. National Transportation Meeting to be held at the La Salle Hotel, Chicago. Further information is available from SAE, 485 Lexington Ave., New York 17, N. Y.

Oct. 26-28—

National Fluid Power Association. Fall Meeting to be held at Hotel Statler, Detroit. Further information can be obtained from NFPA headquarters, 5595 N. Hollywood Ave., Milwaukee 17, Wis.

Oct. 26-28—

International Symposium on Gas Lubricated Bearings to be held at the Shoreham Hotel, Washington, D. C. Symposium is being conducted by the Franklin Institute for the Office of Naval Research. Further information is available from ONR Gas Bearing Symposium, Franklin Institute Laboratories, Philadelphia 3, Pa.

Oct. 26-30—

Society of Photographic Scientists and Engineers. National Conference and Exhibit to be held at the Edgewater Beach Hotel, Chicago. Further information can be obtained from society headquarters, Box 1609, Main Post Office, Washington, D. C.

Oct. 27-28—

Society of Automotive Engineers Inc. National Diesel Engine Meeting to be held at the La Salle Hotel, Chicago. Additional information can be obtained from society headquarters, 485 Lexington Ave., New York 17, N. Y.

Oct. 28-29—

Sixth Annual Computer Applications Symposium, sponsored by Armour Research Foundation of Illinois Institute of Technology, to be held at the Morrison Hotel, Chicago. Additional information is available from M. J. Jans, Conference Secretary, Armour Research Foundation, 10 W. 35th St., Chicago 16, Ill.

Oct. 28-30—

Society of Automotive Engineers Inc. National Fuels and Lubricants

BIG news in electronics for vibration testing

One of the world's largest vibration test systems was recently shipped by MB to the Sperry Gyroscope Company. It featured an electrodynamic exciter of 25,000 pounds force output, a 100 KW high fidelity power amplifier of advanced design, and fully integrated, electronic controls for complex motion tests.

What makes one company a preferred source of supply in its field? Reliability, of course. But among other things, a record of "firsts." Look at MB's record in electronics alone, as applied to vibration:

- first KVA amplifier design for shaker drive
- first automatic sequencing with interlocks
- first completely remote operation
- first amplifier with full current capacity down to 5 cps
- first use of active analog computers
- first application of XY recording technique
- first to achieve low distortion in big-output amplifiers
- first displacement limiter providing protection without complete system shutdown
- first use of high-degree negative feedback around output tubes
- first use of regulated tube filaments

When you need vibration test equipment, make *your* investment in MB quality and capabilities.

MB ELECTRONICS

A DIVISION OF TEXTRON ELECTRONICS, INC.
1056 State Street, New Haven 11, Conn.

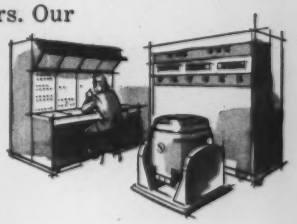
Pioneer and leader in the field of vibration

Circle 427 on Page 19

NEW in looks, new in efficiency, and forerunner of a great new line of MB vibration exciters... that's the new Model C125.

Once again leading the way, MB has achieved a radical step-up in magnetic circuit efficiency. This new shaker, barely larger than its predecessor, develops 10,000 pounds force output... a 43% gain! Conversely, it calls for less amplifier power than any other electrodynamic shaker of comparable force.

Leading companies in missiles, aircraft and electronics look first to MB for progress in complete vibration test systems. It has been that way for almost 15 years. Our "encyclopedia" of vibration experience is yours to draw on... as is the largest, national, field service staff of specialists. Send for full data.



Pioneer and leader in the field of vibration

MB ELECTRONICS

A DIVISION OF TEXTRON ELECTRONICS, INC., 1056 State Street, New Haven 11, Conn.

New breakthrough in vibration exciter performance!

43% more force output.. More efficient utilization of power amplifier!

New UNION readout instruments withstand shock, vibration and extreme temperature changes

Union Switch & Signal's new READALL* readout instrument replaces complicated systems of lights and relays for reading, storing or transferring all types of information for industrial and military applications. It is not to be confused with conventional indicating devices.

Designed to meet requirements of MIL-E-5422D. The new READALL readout instrument is precision-built and provides instantaneous and continuous operation under conditions of shock, vibration and extreme ranges in temperature. The digital display includes characters in numerical sequence from 0 to 9 plus two blank spaces. 7/32-inch characters can be illuminated red or white as desired; when not illuminated, they appear white against a black background.

Reliability. Performance through one million random operations is an inherent feature of the new READALL instrument. Each module is gasket-sealed in its case to exclude moisture and seal out foreign particles. An especially thin enclosed DC motor, containing ball bearings, permits more efficient operation.

Modular Construction. A unique feature of the readout instrument is its modular construction. It can be used individually or in groups to display multiple characters in a single case.

Direct Code Translation. The operation of the READALL readout instrument is based on a positioning system using a four-bit code. The visual display is the result of a direct electro-mechanical conversion of a binary signal to a decimal read-out. There is no need for additional conversion equipment. Separate code and motor circuits permit the use of the readout instrument in low-level circuitry.

Electrical and Visual Data Storage. Once positioned, the information is displayed until a new code is transmitted to the instrument. No power is consumed while the information is retained. This data may be stored or read-out electrically for further transmission or recording.

Operate Time. The operate time varies from 0.1 second to 1.0 second depending on character position.

Weight and Size. Maximum weight including case is seven ounces; without case, four and one-half ounces. Size encased is $5\frac{13}{64}$ inches long, $1\frac{47}{64}$ inches high and $\frac{39}{64}$ inch wide. The new READALL instrument is designed for operation over a temperature range of −54°C to +71°C in humidities up to 100% and altitudes up to 70,000 feet. For more information, write for Bulletin 1019.

*Trademark

"Pioneers in Push-Button Science"

UNION SWITCH & SIGNAL
DIVISION OF WESTINGHOUSE AIR BRAKE COMPANY
PITTSBURGH 18, PENNSYLVANIA

Meeting to be held at the La Salle Hotel, Chicago. Further information is available from SAE, 485 Lexington Ave., New York 17, N. Y.

Oct. 29-30—

Metals Casting Conference to be held at Purdue University. Sponsors are Purdue's School of Metallurgical Engineering and the American Foundrymen's Society. Further information can be obtained from C. T. Marek, Michael Golden Engineering Laboratories, Purdue University, Lafayette, Ind.

Oct. 29-30—

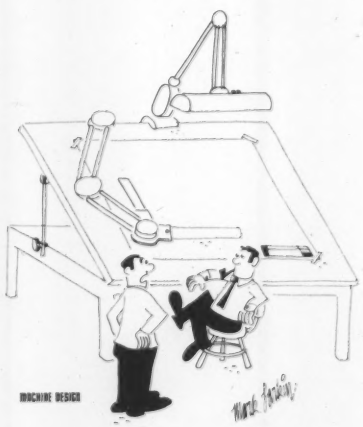
Society for Advancement of Management. Annual Fall Conference to be held at the Hotel Statler, New York. Additional information is available from society headquarters, 74 Fifth Ave., New York 11, N. Y.

Oct. 30-Nov. 1—

American Society of Refrigerating Engineers. Semiannual Meeting to be held at the Traymore Hotel, Atlantic City, N. J. Additional information can be obtained from society headquarters, 234 Fifth Ave., New York 1, N. Y.

Nov. 2-5—

Air-Conditioning and Refrigeration Institute. Exposition of the Air-Conditioning and Refrigeration Industry to be held at Convention Hall, Atlantic City, N. J. Further



"How do you rate all these big projects?"

information is available from institute headquarters, 1346 Connecticut Ave. N.W., Washington, D. C.

Nov. 2-6—

American Society for Metals. National Metal Exposition and Congress to be held at the International Amphitheatre, Chicago. Further information is available from ASM headquarters, Metals Park, Novelty, Ohio.

Nov. 2-6—

Society for Nondestructive Testing. 19th Annual Convention to be held at the Hotel Hamilton, Chicago. Further information can be obtained from R. G. Strother, Magnaflux Corp., 25 W. 43rd St., New York 36, N. Y.

Nov. 3-5—

Mid-America Electronics Conference to be held at the Municipal Auditorium, Kansas City, Mo. Additional information can be obtained from Ira J. Jones, Bendix Aviation Corp., P. O. Box 1159, Kansas City 41, Mo.

Nov. 4-6—

American Nuclear Society. Winter Meeting to be held at the Sheraton Park Hotel, Washington, D. C. Further information can be obtained from society headquarters, 86 E. Randolph St., Chicago 1, Ill.

Nov. 4-6—

National Automatic Control Conference, to be held at the Sheraton Hotel, Dallas. Conference sponsor is the Institute of Radio Engineers Professional Group on Automatic Control, with official participation by American Institute of Electrical Engineers, Instrument Society of America, and the IRE Professional Group on Industrial Electronics. Further information can be obtained from M. L. Barnett, 1095-C Magellen Circle, Dallas 18, Tex.

Nov. 9-11—

Steel Founders' Society of America. 14th Technical and Operating Conference to be held at the Carter Hotel, Cleveland. Additional information is available from society headquarters, 606 Terminal Tower, Cleveland 13, Ohio.

YOURS for the asking...

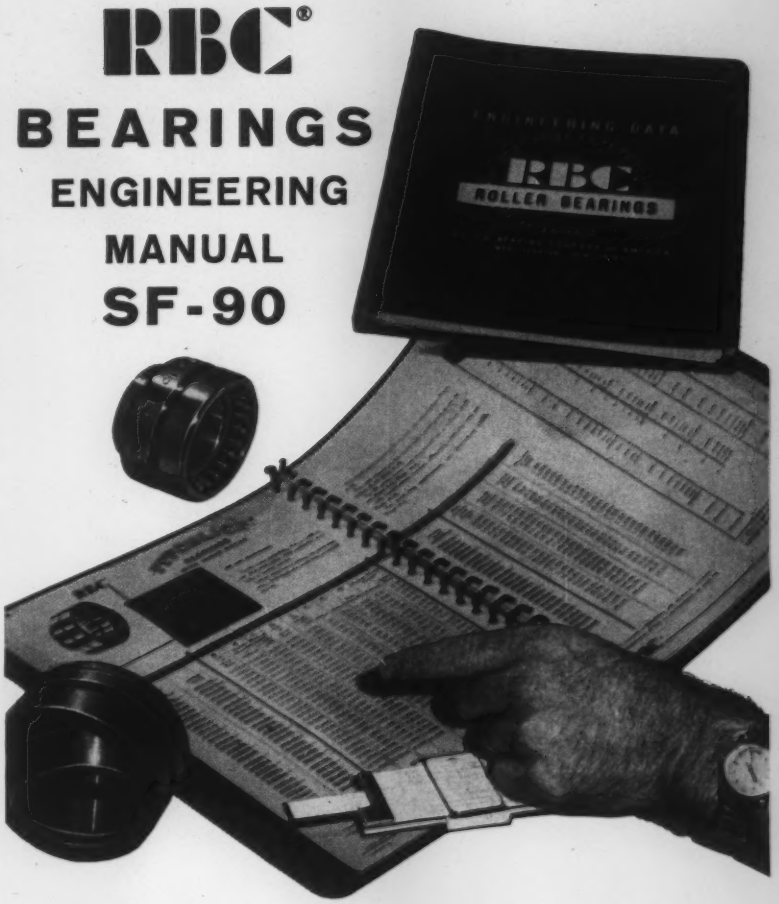
RBC®

BEARINGS

ENGINEERING

MANUAL

SF-90



NEW from cover to cover . . .

Designed to give the engineer "finger-tip" data on the complete line of RBC BEARINGS . . .

Pitchlign
Sealed Pitchlign
Pitchlign Roller Follower
Sealed Pitchlign Roller Follower
Pitchlign Aircraft
Self-aligning Bushing Assembly
Metric Cylindrical

Large, easy to read specification tables plus a convenient Nomogram for quick, accurate determination of bearing capacity. Permanent, multi-ring binder permits access to individual pages and readily accepts additional inserts to keep the manual "up-to-the-minute".

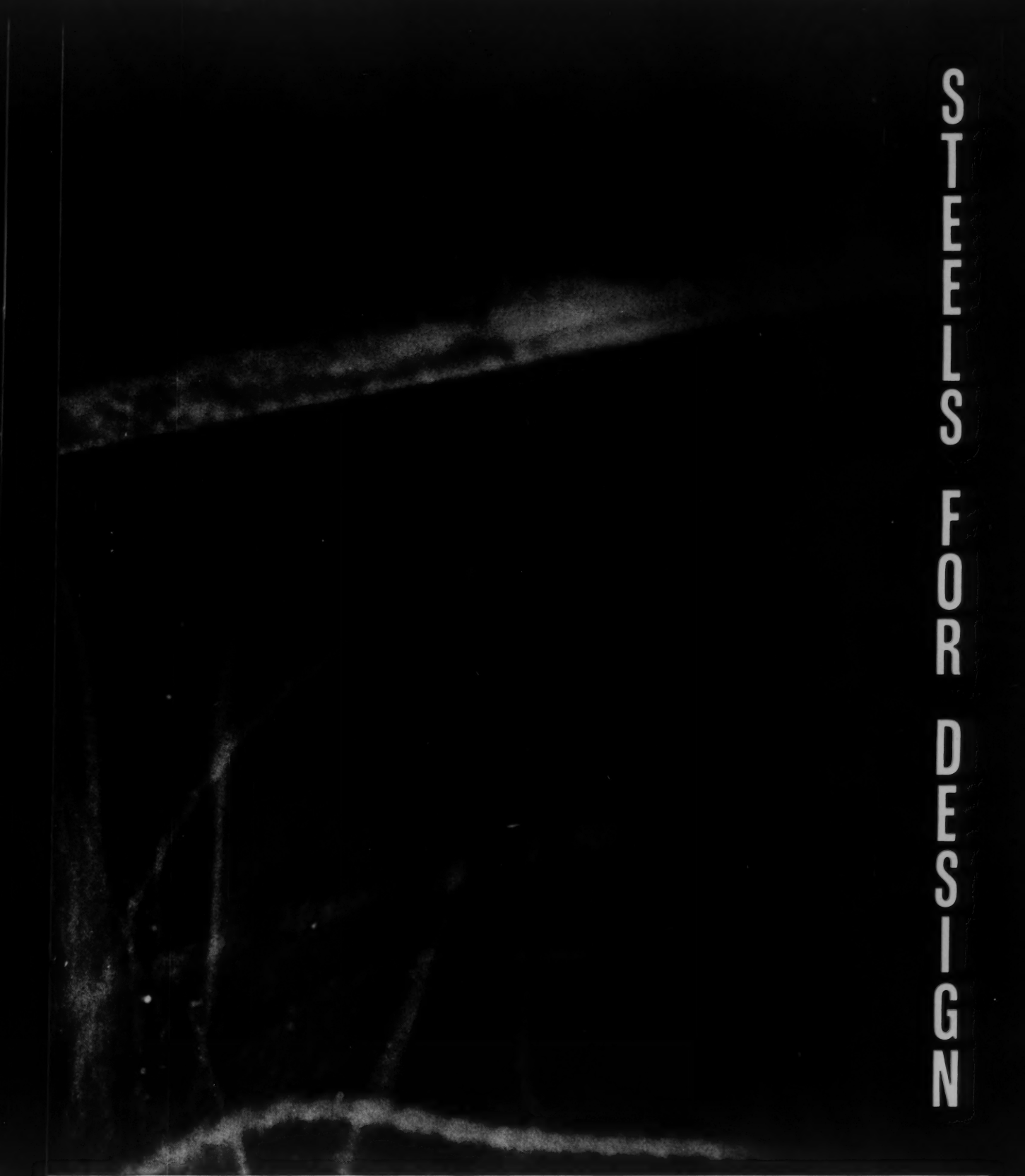
FREE just write for your personal RBC BEARINGS manual ....

ROLLER BEARING COMPANY OF AMERICA
Sullivan Way, West Trenton, N.J.

Circle 429 on Page 19

Jointly, We've come a long way since man first found that he could unite pieces of metal by

No matter what technique you use, the finished joint is best when the welded material is steel.

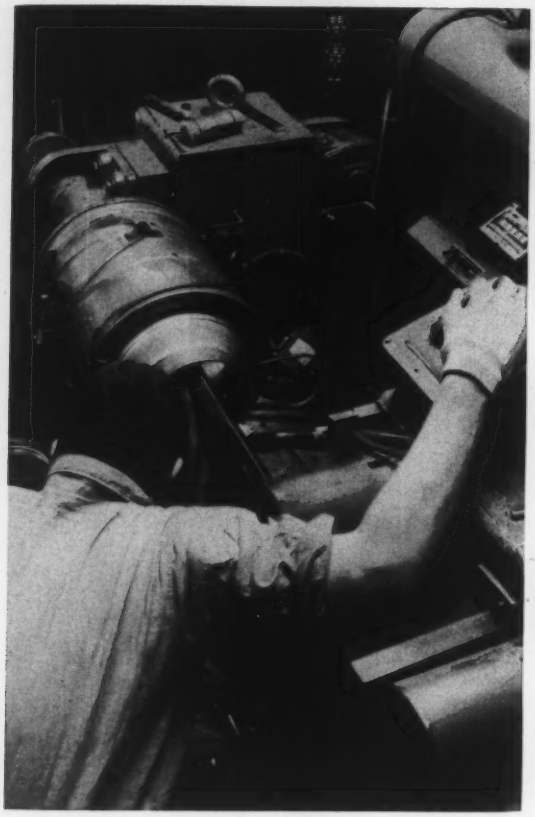


STEELS FOR DESIGN

beating them together while they were hot. Now there are almost 40 different welding techniques.

Above, you see a close-up photograph of arc-welding. For a more complete picture of welding, turn the page. ▷ ▷ ▷

Please direct inquiries to advertiser, mentioning MACHINE DESIGN



STEELS FOR DESIGN

Stainless Steel makes a flawless milk can—Milk cans have to be surgically clean. That's why the John Wood Company makes them from Stainless Steel, with **welded** joints. Here, you see a "Heli-arc" welding machine that was specially designed to weld the inside bottom and outside bottom of the can in one operation. The welding head is retracted to the breast of the can where again, the inside and outside welds are done in one operation. A nipple is gas-welded to the bottom of the can and all the joints are polished to a mirror finish—ready to pass microscopic inspection. Because of the outstanding design and fabrication processes developed by this company, they are now equipped to produce 50% of all the Stainless Steel can requirements for the entire dairy and vending machine industries.

USS "T-1" Steel stops saddle block failure—A saddle block links the dipper stick to the boom of a power shovel (see arrow above) and provides the digging effort. It has to withstand tremendous stress and shock—failures are not uncommon. But one operator had too many saddle block replacements so he asked J. B. Lund's Sons Co. to make a stronger unit. The conventional solid cast steel or forged steel block would have been too vulnerable, so the additional strength had to come from a **welded** assembly of strong steel plates. But the higher carbon content that increases the strength of most types of steel also decreases the weldability. They solved the dilemma with USS "T-1" Constructional Alloy Steel. "T-1" brand is a **low** carbon, quenched and tempered alloy steel with tremendous strength—100,000 psi minimum yield strength. The photo shows the finished block made from "T-1" steel plates that were edge-welded 1¼" deep. This block has never failed.

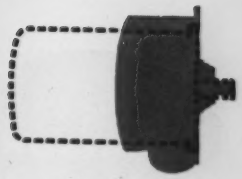
High Strength Steel cuts dead weight—You can stand beside the Carquinez Strait in California and size-up thirty years advancement in bridge building. There are two spans there, side-by-side; one is 31 years old, the other was completed last year. The builders of the new span saved 2,128 tons of steel because they designed the new Carquinez Strait Bridge with USS TRI-TEN High-Strength Low-Alloy Steel and USS "T-1" Constructional Alloy Steel. With yield strength levels of 46,000 psi min. and 90,000* psi min., respectively, these ultra-strong steels permitted thinner, lighter truss members that were shop-welded instead of riveted. 100% efficiency butt welds saved 20% in the weight of tension members by providing extra material at the holes for the connection bolts. The smooth, rivet-free surfaces are less vulnerable to corrosion . . . save thousands of dollars in maintenance.

USS, "T-1" and TRI-TEN are registered trademarks

United States Steel (USS)

*Now 100,000 psi for plates up to 2½ inches.

These are both 5 hp motors!



SAME NEMA RATING IN
60% LESS SPACE

PERFORMANCE-PROVED RADIAL
AIR-GAP DEPENDABILITY

New-product news from Louis Allis

60% shorter—
but with radial air-gap design!

New Louis Allis Pancake Motor preserves all the advantages of conventional motor construction

The new Louis Allis Pancake Motor is your solution to trouble-free power in any space-cramped motor application.

The Pancake is a remarkably short flange-mounted motor — up to 60% shorter and 33% lighter than standard motors of the same rating! And it is built in *conventional* radial air-gap design!

It's done by an ingenious forming process which literally compresses the end coils of a conventional radial air-gap motor into an exceptionally short length. The result is a compact, light motor ideally suited for horizontal or vertical mounting on machine tools, roof ventilating fans, or *any* close-quarter installation where space is a critical design factor.

What's more, this is achieved without sacrificing a single desirable characteristic: the stator still contains the same iron and copper as standard Louis Allis motors . . . standard NEMA service factor is maintained . . . high insulative values are retained by using proved Louis Allis varnishes and new insulating techniques . . . over-sized pre-lubricated bearings are used to guarantee long bearing life . . . and the entire motor is enclosed in an industrial-type cast-iron housing designed to shrug off abuse!

The housing and flange are cast in one piece: this permits extra-accurate internal machining which extends bearing life and reduces noise levels to a new low.

Investigate the Pancake Motor through your local Louis Allis District office. Sized from 1 to 15 hp, at 1800, 1200, and 900 rpm, in open drip-proof and enclosed non-ventilated or fan-cooled enclosures. Write for Bulletins 2100 and 2150 to the Louis Allis Co., 459 E. Stewart St., Milwaukee 1, Wisconsin.

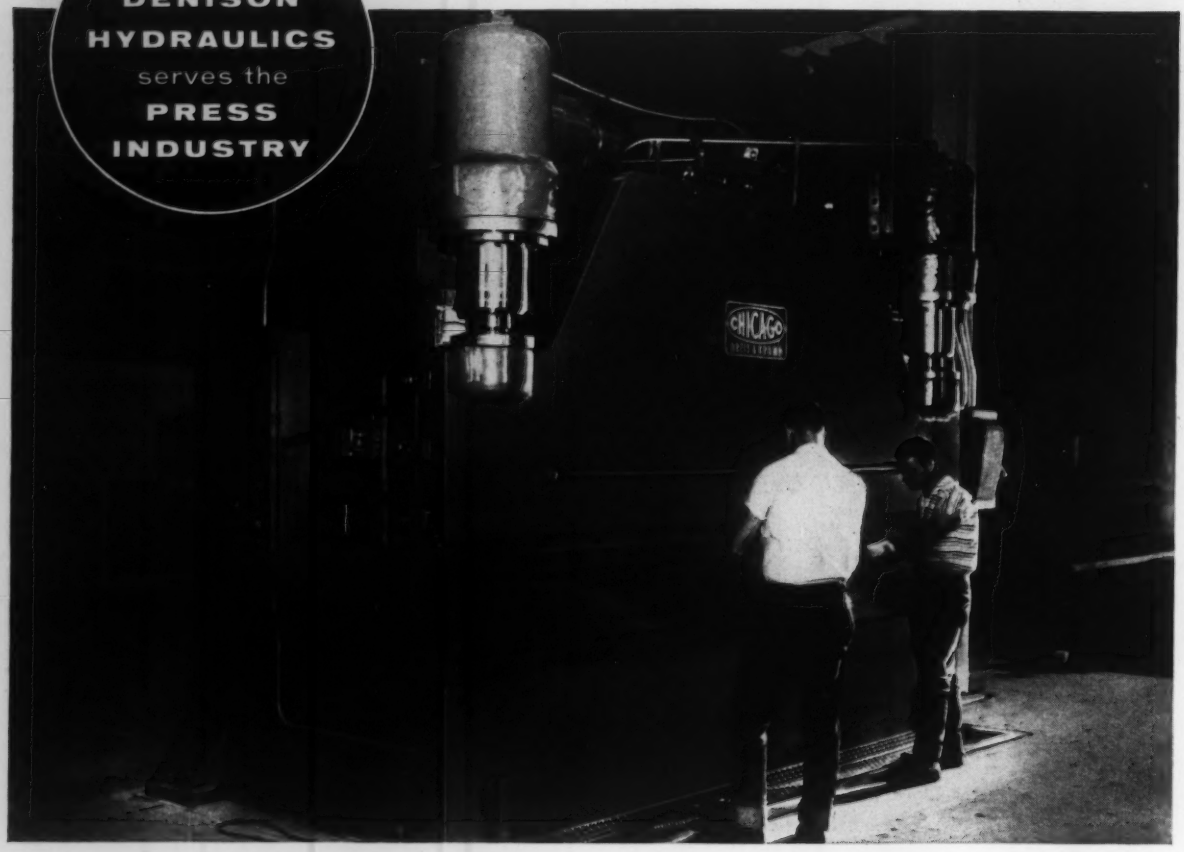
MANUFACTURER OF ELECTRIC MOTORS AND ADJUSTABLE SPEED DRIVES

LOUIS ALLIS

Circle 430 on Page 19

How **DENISON HYDRAULICS** serves the **PRESS INDUSTRY**

CHICAGO STEEL HYDRAULIC PRESS BRAKE, *14" bending length, Model 300-HF-12. The unit was built by Dreis & Krump and utilizes 3,000 psi hydraulic system, incorporating Denison axial piston and vane-type pumps.*

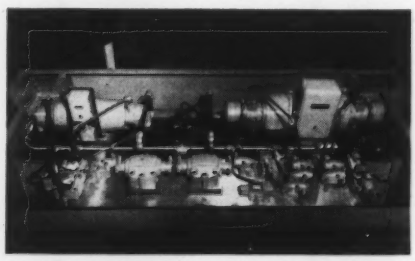


How this **DENISON** 3,000 psi hydraulic system works for **DREIS & KRUMP**

This hydraulic press brake—built by Dreis & Krump Manufacturing Company of Chicago, Illinois—has multiple speed control, rapid approach and return, slow pressing speed for full-tonnage work. Control is attained through a hydraulic system utilizing Denison axial piston pumps, vane-type pumps and hydraulic controls.

In addition, a level control operated by a servo system compensates for any differential in travel of either cylinder to maintain accurate parallel of the ram with the bed. Tonnage control enables the operator to pre-select pressures over the full tonnage range to assure maximum production to dies and work pieces.

Simple in design, the system affords maximum versatility and reliability. Your Denison representative, a specialist in hydraulics, will gladly help in applying the best possible system to your hydraulic machining. Call him.



HYDRAULIC COMPONENTS *for 3,000 psi system for regulating speed and pressure of ram travel.*

DENISON ENGINEERING DIVISION
American Brake Shoe Co.
1240 Dublin Road • Columbus 16, Ohio

Denison Stocking Branch Offices: CHICAGO • DETROIT
LOS ANGELES • HOUSTON • ATLANTA • NEWARK • CLEVELAND

HYDRAULIC PRESSES • PUMPS • MOTORS • CONTROLS

Denison and Denison HydrOILics are registered trademarks of Denison Eng. Div., ABSCO

DENISON HydrOILics

Circle 431 on Page 19

Circle 432 on Page 19 for Air Valves→

PARKER-HANNIFIN FLUID-SYSTEM COMPONENTS

From HANNIFIN... unit construction to give you air valves that do more jobs

Hannifin ⅜" four-way valve with "universal" base and new Speed Control section. Single-solenoid actuated. 10 other actuators available.

One of the versatile—and most popular—Hannifin air control valves is this "CC" series, single-solenoid model. It is available for either ¼" or ⅜" air lines and is gasket-mounted to its own base. This particular base (one of three choices offered) can either be O-ring gasketed to your manifold or mounted over an opening in your bracket or machine. It will receive all four lines from below or take the inlet line from below and the two cylinder lines out one side. Or, you can make all connections at the sides.

When it comes to actuation, Hannifin offers an even wider selection: hand, foot, cam, pressure, single or double solenoid.

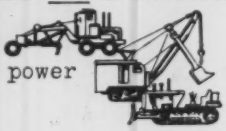
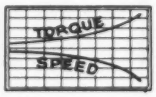
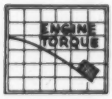
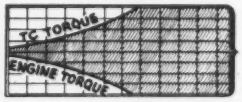
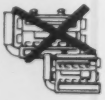
When necessary, you can remove this entire valve from its base without disconnecting air lines. Or, the exclusive "spool-poppet" can be replaced without even breaking electrical connections.

The "CC" series, like all Hannifin valves, is designed with "full flow" internal passages as large or larger than its rated pipe size.

You will find these and most other Hannifin valves described in Hannifin's new "Valve Finder." Get your copy from your Hannifin man, listed in the A-Z volume of Thomas' Register, or write:

HANNIFIN COMPANY
525 South Wolf Road • Des Plaines, Illinois

A DIVISION OF PARKER-HANNIFIN CORPORATION

HERE'S HOW AND WHY A NATIONAL TORQUE CONVERTER on your heavy equipment can give you more usable power  from your engines, reduce excessive maintenance, and increase machinery life. When equipment driven by a direct-connected engine is overloaded engine speed drops. So does the "Torque" which is the turning-force delivered by crank-shaft. If the overload continues, the engine stalls and its torque drops to zero. When equipment driven through a NATIONAL TORQUE CONVERTER is overloaded, it cannot stall the engine! Engine speed and engine torque both "level-off" in their most efficient zones, and stay there! The torque-converter shaft slows down but at the same time its torque increases! If equipment overload increases, the converter output shaft finally stalls, but at this point it is delivering maximum torque.  Now if you put the diagram showing how engine torque drops  under equipment overload, with the diagram showing how torque converter torque increases under the same overload, you'll see between the two a  "bonus-power" zone of extra usable power that the NATIONAL TORQUE CONVERTER gives you. Power that makes an oversize engine  or "babying" of equipment unnecessary. Furthermore, shocks and strains that batter and age equipment are absorbed in the converter. Machinery lasts longer with less maintenance. If YOU own or operate heavy equipment (with 100 to 1000 hp drives) ask for performance records and recommendations.

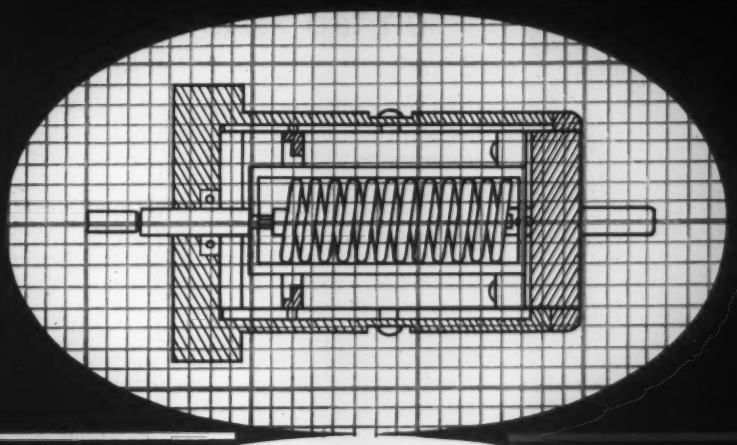
THE NATIONAL SUPPLY COMPANY

Subsidiary of Armco Steel Corporation

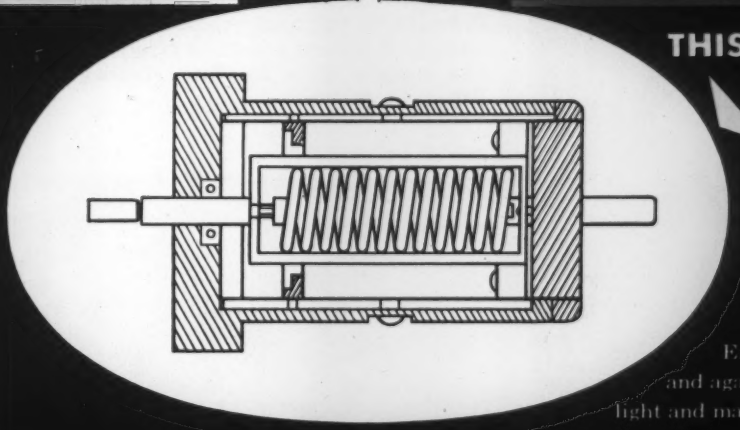
TWO GATEWAY CENTER, PITTSBURGH, PA.

When you specify

Drafting costs are cut in half



Quickly and accurately rendered to scale with blue grid lines to guide you. Guide lines are on back of drawing surface enabling you to erase and erase without disturbing them.



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Blue grid lines have disappeared completely giving sharp, easy-to-read copies.

Try Clearprint's perfect working surface with a 2H pencil—then with a pen. Lines are sharp and clear. Erase and draw the lines again and again. Now hold Clearprint to a light and make reproductions. No ghosts! Then test your present sheet.

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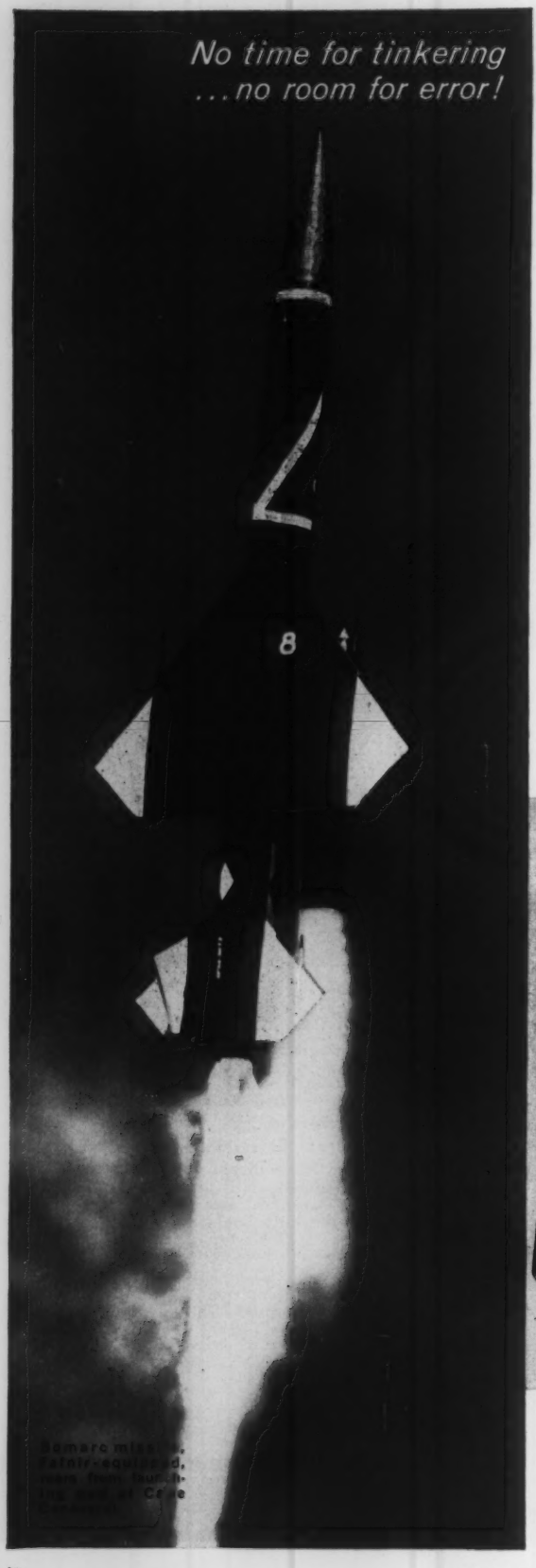


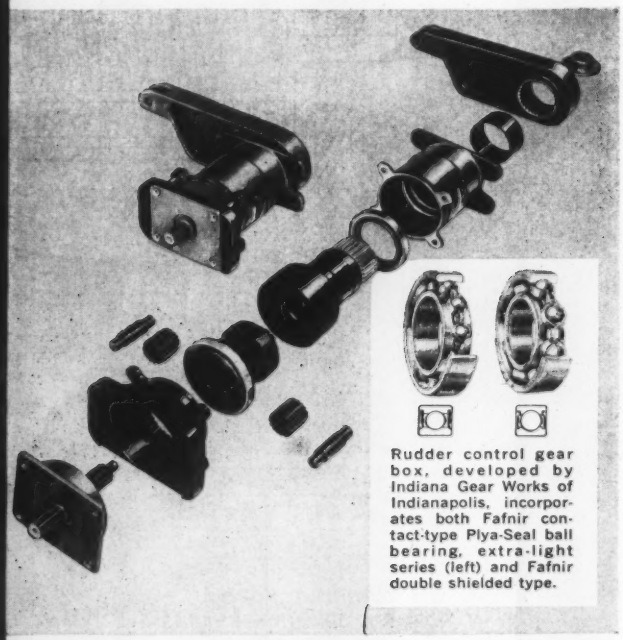
Fafnir Ball Bearings help keep Bomarc missiles "on tap"...and on target!

Used in the outboard rudder control gear box of the Boeing Bomarc, Fafnir ball bearings meet several important design requirements for Indiana Gear Works, designers of this vital missile component.

Fafnir prelubricated and shielded ball bearings and bearings with Plya-Seals, for example, provide positive, built-in protection against contaminants. These bearings remain trouble-free, require no servicing, help keep the Bomarc ready to go at moment's notice.

Uniform high quality is another must. Fafnir quality control insures bearings that consistently meet exacting tolerance and dimensional requirements, installation after installation.

Your own design problem may not involve missilery. But if it calls for ball bearings, look to Fafnir. You'll find the diversity of line and breadth of experience that assure precise answers. Write The Fafnir Bearing Company, New Britain, Connecticut.



Rudder control gear box, developed by Indiana Gear Works of Indianapolis, incorporates both Fafnir contact-type Plya-Seal ball bearing, extra-light series (left) and Fafnir double shielded type.

FAFNIR
BALL BEARINGS

Circle 435 on Page 19

3 STOCK RELAYS for Day-In Day-Out Reliability

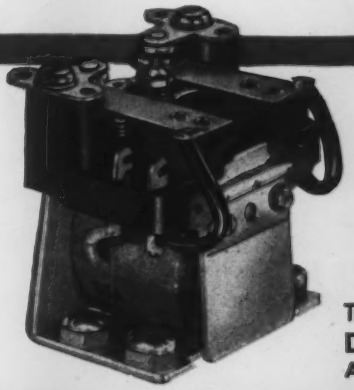
Type **DO** AC-DC

For Severe Shock and Vibration

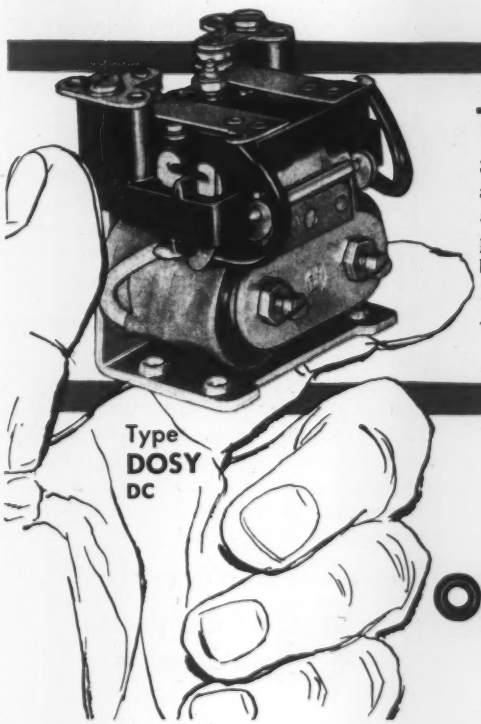
A rugged relay, particularly adaptable to aircraft and mobile applications. Design of molded parts around contact arms prevents mechanical injury. Available in twenty-three 3-pole and 4-pole types. *Coil Wattage:* 3.00 watts, DC operation; 6.00 watts, 60 cycle AC. Maximum temperature rise 45° C, DC; 75° C, AC. *Coil Operating Voltages:* from 6 to 230 VAC (60 cycles) and 6 to 220 VDC. *Contacts:* Fine silver. Rated for 115 VAC or 32 VDC, non-inductive load. *Weight:* 3-pole, approximately 5 ounces; 4-pole, 6 ounces.

Compact and Lightweight

A general-purpose relay of wide application. Handles loads usually demanded of much larger relays. Meets rigorous aircraft relay standards. Twenty single-and double-pole types. *Coil Wattage:* 2.5 watts, DC; 3 watts, 60 cycle AC. Maximum temperature 45° C, DC; 65° C, AC. *Coil Operating Voltages:* from 6 to 230 VAC (60 cycles) and 6 to 220 VDC. *Contacts:* Fine silver is standard. Rated for 115 VAC or 32 VDC, non-inductive load. *Weight:* Approximately 4 ounces.



Type **DOS** AC-DC



Type **DOSY** DC

Twin Coils for Extra Sensitivity

Similar in construction to Model DOS. The DOSY relay is adaptable to a wide range of electronic applications such as plate circuit controls or as overload or underload controls in DC circuits to signal attainment of predetermined current levels. Four single- and double-pole types. *Coil Wattage:* 1.00 watt, with maximum temperature rise of 45° C. *Contacts:* Fine silver. Rated for 115 VAC or 32 VDC, non-inductive load. *Weight:* Approximately 4½ ounces.

Write for Stock Catalog 30

Also other quality relays of many types

RHEOSTATS • RESISTORS • RELAYS
TAP SWITCHES • R.F. CHOKES
VARIABLE TRANSFORMERS
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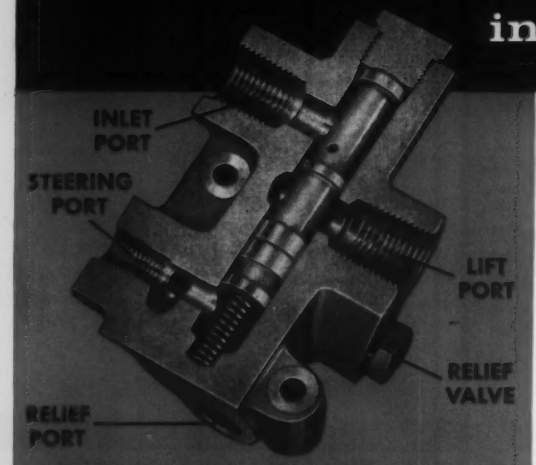
Circle 436 on Page 19

DYNAMIC DIFFERENCE

in hydraulic performance



BULLETIN HY1 contains performance and installation data on the complete line of Webster positive displacement gear type pumps, fluid motors and valves. Write for your copy.

Call the man from Webster

. . . he's one of a staff of engineers, specially trained in hydraulic application. He can help you solve special problems when hydraulics become a part of your design!

photo courtesy of THE FRANK G. HOUGH CO., Libertyville, Illinois

Webster

HIGH CAPACITY FLOW DIVIDERS

Material moving magic! 20 cubic feet at a bite, this highly maneuverable front-end loader cuts big piles down to size — without missing a beat. Hydraulics play an important roll here — in power steering, in powering the bucket. But there's only *one* hydraulic pump. A Webster flow divider supplies *both* hydraulic circuits — and permits each to be operated *simultaneously* at different pressures from a *single pump!*

There are more advantages . . . Webster flow dividers operate at pressures up to 2000 psi, capacities to 60 gpm. They're small, compact to fit easily in tight quarters on mobile equipment. Adapt easily and economically to your product and the job.

When *you* plan hydraulics, plan on Webster . . . *for the dynamic difference that pays!*

OIL HYDRAULICS DIVISION

WEBSTER ELECTRIC

RACINE · WIS

our 50th year

franklin adv. H-115

Circle 437 on Page 19

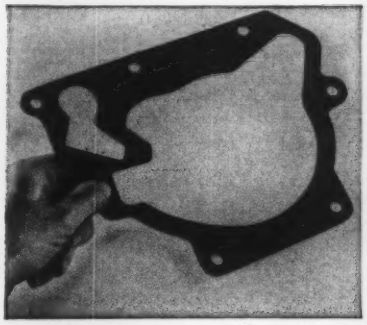
Technical data for gasket design and selection

NUMBER SIX

New asbestos gasket will not crush or extrude under heat and pressure

The combined effects of high flange loads and ambient temperatures in the 300° F. range impose severe demands on gasket materials.

In some applications—as, for example, in modern automotive transmissions—these operating conditions can cause extrusion and crushing of conventional gasket materials.



Effective sealing under such conditions requires a dense material with unusual resistance to crushing at high temperatures. A material that meets these requirements is Accopac AN-890, a new Armstrong asbestos gasket.

Under test loads of 100,000 psi at temperatures of 350° F., AN-890 shows no noticeable extrusion or crushing. Indications are that the excellent torque retention properties of AN-890 would not be impaired even at much higher temperatures.

AN-890 is made by a beater-saturation process pioneered and patented by Armstrong. This method coats the fibers uniformly with a nitrile-type latex rubber binder and links them so tightly that crushing and extrusion are eliminated in normal applications.

With all its advantages, AN-890 costs less than conventional compressed asbestos materials. For more information, send for a copy of bulletin IND-915.

How internal pressure affects the selection of resilient gasket materials

Resilient gasket materials are most widely used where internal pressures are relatively low (e.g., up to 100 psi).

Because of pressure surges or intentional design, resilient materials sometimes are operated at internal pressures considerably above 100 psi. In such cases, the possible effect of the higher pressures should be taken into account.

Internal pressure acts against the gasket in two ways:

1. *Hydrostatic end force.* This tends to move the flanges apart and is proportional to the internal pressure. The extent to which this happens, of course, determines how much the load on the gasket is reduced, and how much the risk of leakage is increased.

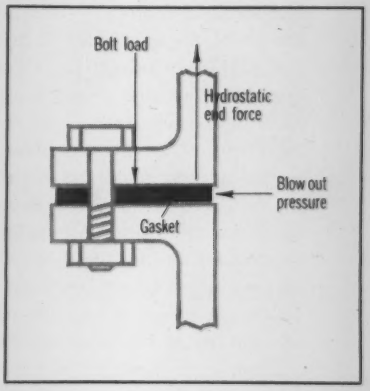
2. *Blowout pressure.* The sealed fluid or gas exerts direct pressure on the inside perimeter of the gasket. If this pressure is high enough, it will blow the gasket out of the joint.

The effect of high internal forces must be compensated for in the design of the joint. The obvious first step is to be sure that the flanges are capable of imposing the required unit load on the gasket. This involves the rigidity of the flanges and the number of bolts, their size, spacing, and torque values.

The second step is evaluation of the gasket material to be used. High unit loads dictate the choice of a material that will not extrude or rupture under high pressures. This usually means a dense fiber or asbestos material. Several compositions suitable for service under high flange loads are available in the Armstrong Accopac line of beater-saturated gasket materials.

Other factors such as the nature of the contained fluid and the temperature at the gasket line also have a bearing on the selection of a gasket material for service where internal pressures are high.

In summary, where internal pressures are involved, it is especially desirable to consider the joint as a unit. The flange design, the gasket material, the confined fluid, and the temperature should be considered in relation to each other.

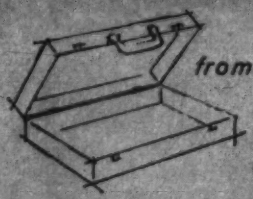


Detailed information on the effect of internal pressures and other problems of gasket selection, design, and performance are included in the new Armstrong Gasket Design Manual. Write today for your copy of this helpful 32-page book.

Send today for your copy of new Gasket Design Manual, IND-763. Write Armstrong Cork Company, Industrial Division, 7110 Dean Street, Lancaster, Pa.

Armstrong GASKET MATERIALS

. . . used wherever performance counts



from the case of the A. O. Smith Motor Man . . .

A MOTOR THAT SET INDUSTRY STANDARDS:

LOOKING AHEAD FOR NEW JOBS

Here's a motor with ambitions! Sealed-capsule fractional-hp motors — designed originally to solve the problems encountered in the air-conditioning and pumping industries. Consider their performance qualifications — you'll see why they've only scratched the surface . . . why they'd be ideal for such equipment as compressors, machine and woodworking tools, materials handling equipment, etc.

Qualifications? For one thing, sealed-capsule design (end-mounting, end-sealing of switch, actuator, thermostat and terminal board) has eliminated the biggest cause of single-phase fractional-hp motor failure. It's easy to see why these motors keep on the job under the most severe working conditions.

Unique installation flexibility has also resulted from this functional component grouping. Ball bearings and closer bearing centers assure minimum noise and shaft play . . . permit mounting anywhere in any position. Air is practically silenced through a unique ventilation design . . . magnetic noises are reduced to absolute minimum by special machining and assembly processes. Let us put one on your equipment. Compare it with sleeve-bearing motors. For complete data, please use the handy coupon below.

Available in single or polyphase — rigid or resilient base.

(Cut on dotted line, fold, staple and mail. No envelope or postage necessary.)

☐ Please send me more comprehensive details and application data on the A. O. Smith line of fractional-hp motors — 1/3 to 2 hp — that feature sealed-capsule design.

☐ I'd like to test your sealed-capsule motor.

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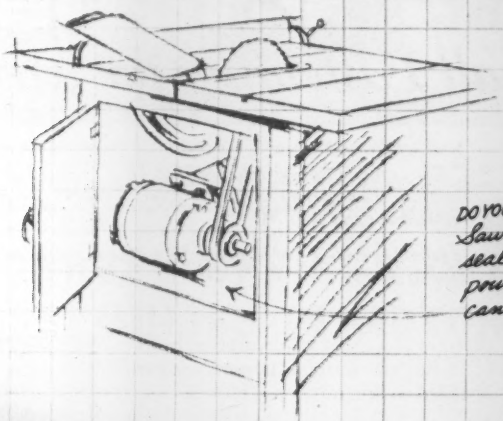
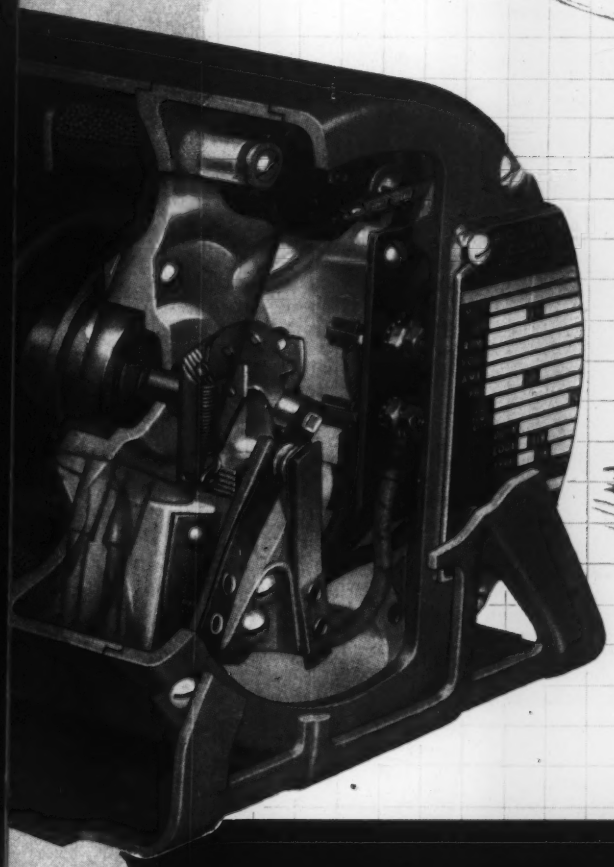
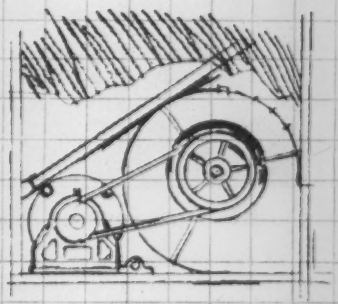
Scan the drawings below for ideas on how the sealed-capsule design can work into your plans

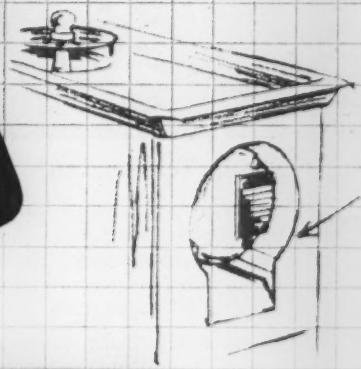


DO YOU HAVE A MOTOR CONTAMINATION PROBLEM? Sawdust and other foreign matter is sealed out of motor end-capsule on this powersaw application. Ventilating air cannot contaminate vital parts.

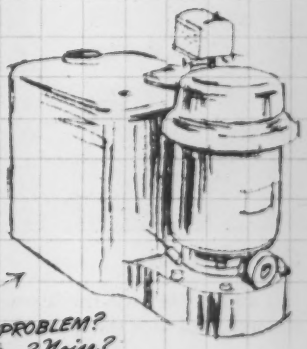


IS SPACE A PROBLEM? On this air-conditioning unit, absence of externally mounted capacitor (doghouse) permits installation in tight quarters without damage. Has eye appeal too.





IS EASE OF MAINTENANCE A PROBLEM? End-plate of sealed-capsule motor shields all functional parts . . . is easily removed for inspection in extremely limited areas as on this meat-cutting machine.



WHAT IS YOUR PROBLEM? Contamination? Noise? Maintenance? Appearance? Thrust? Space? The A.O. Smith sealed capsule motor was designed around just such "specs". Why not try it for your application?

Truly functional component grouping. Switch, actuator, capacitor, thermostat, and terminal board are all conveniently end-mounted . . . all completely protected against contamination and mechanical damage.

Note adjustable starting switch! On every A. O. Smith single-phase motor, switch is adjusted after assembly by turning a self-locking screw to achieve a pre-set clearance between the switch button and actuator. This assures proper contact alignment and positive switching action . . . guarantees maximum life for every motor.

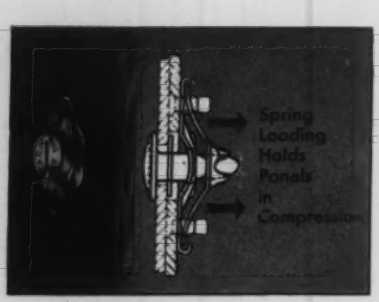
Circle 438 on Page 19

Quick-Opening Fasteners

Selecting Small Fastenings for Metal Closures

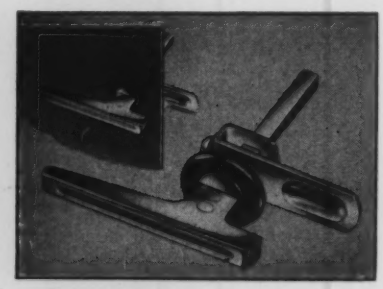
*"Use captive fasteners wherever feasible . . . Avoid the use of loose washers and loose nuts . . . Fasteners on equipment covers should be operable either with no tools or with standard hand tools"**

(John D. Folley, Jr. & James W. Altman, Research Scientists, American Institute for Research)



Quarter-Turn Fastener

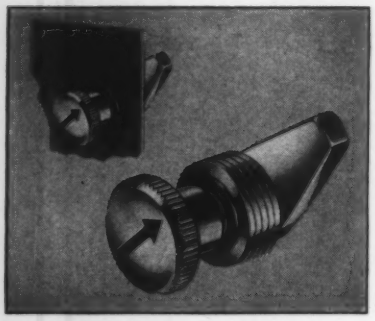
Lion Fasteners open and close with a ¼ turn, hold sheets tightly under the compression of a rugged spring. Quickly operated and fully retained in the outer panel, they are approved under U. S. Government military specifications. Stud and receptacle float for easy alignment and simplified hole preparation. Flush, oval, wing, knurled, ring, and key head styles available. Sizes—No. 2, No. 5, and High Strength for extra heavy duty.



Cabinet Latch

Just drill a hole, push the fastener stem through, and slide the special push-on clip into place. No welds, screws, bolts or rivets: the fastener is permanently installed in seconds!

Adjustable to any grip length or panel thickness, the pawl is fixed in place by a single set screw. The fastener's brightly finished knob is set off by a plated washer. Also furnished with screwdriver operated flush head.

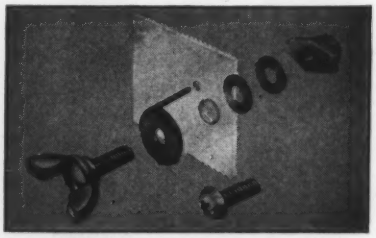


Spring Tension Latch

For fastening slide-out drawers and hinged panels the Southco Arrowhead Latch is recommended. It locks or opens with a quarter turn yet occupies less than ½" inside space.

Doors are held under spring tension—a push against the arrowhead knob relaxes this tension, allows operation with fingertip ease. Drill a single hole for installation—no fastening to the door is necessary No striker plate is needed.

Pawl stop is eliminated—arrowhead shows at a glance exact position of pawl.



Adjustable Panel Latch

Small doors and panels can be fastened with greatest speed and lowest cost with the Southco Adjustable Latch.

The entire fastener is quickly installed through two holes punched in the door; no bolts or rivets are needed.

It operates with a quarter turn, requires no striker plate. An extra twist after the nylon pawl is engaged pulls up the door to form a seal and eliminate vibration.

Available with wing, knurled, or Phillips head.

Free Fastener Handbook

Send for your free copy of Fastener Handbook No. 9, just released. Gives complete engineering data on these and many other special fasteners. Forty-eight pages, in two colors. Write on your letterhead to Southco Division, South Chester Corporation, 237 Industrial Highway, Lester, Pa.

SOUTHCO FASTENERS
LION

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* *Quotation from "Designing Electronic Equipment for Maintainability"; Machine Design, July 12, 1956.*

Circle 439 on Page 19

ISSUE NO. 16

the neg'ator® sketchbook

The NEG'ATOR® Spring is a new basic mechanical component—a coiled band spring which extends many times its original size without the increasing force common to conventional springs. Used as an extension spring, a motor, band, clamp, or clip, this revolutionary new constant-force component upsets all previous spring principles by doing what springs have never done before.

NEG'ATOR® BRUSH SPRINGS CUT COSTS, SIMPLIFY HOLDER ASSEMBLIES IN MOTORS, GENERATORS

NEG'ATOR springs, used as brush springs in rotating electrical equipment, give designers an unusual opportunity to simplify holder assemblies, obtain better commutation, solve problems of vibration, cut costs.

Unlike conventional springs, NEG'ATORS exert constant pressure on the carbon brush through all stages of wear. Thus, adjustment and adjusting devices are unnecessary and holders can be simpler in design, saving cost. Changing brushes becomes an exceedingly simple job.

On this and the next page are several applications illustrating the advantages offered by NEG'ATOR brush springs.

On a Fractional HP Motor for Vibrators

NEG'ATORS are used in two sizes of concrete vibrators made by Master Vibrator Co. for lowering into freshly poured concrete to assure settling while wet and plastic.

In designing the small motors to power these vibrators, Master Vibrator engineers solved problems of brush bounce and arcing inherent in the vibrating equipment by using constant-force NEG'ATOR springs made of cobalt-base, high strength alloy. Unlike conventional springs where load changes with deflection, the NEG'ATOR springs exert the same force on the brushes, holding them against the commutator without weakening under vibration. Proper commutation with minimum arcing due to bounce is provided despite the fact that the vibrators are designed to vibrate up to 15,000 times per minute with an amplitude of $\frac{1}{16}$ inch.

Each brush spring assembly consists of two .002 in. alloy strips, 1 in. long x .125 in. wide with a maximum coil diameter of $\frac{5}{32}$ inch.

(*continued on reverse of this page*)

FIG. 2. Model "U8" Master Vibrator showing tubular housing containing fiber motor end, brush holder with two NEG'ATOR springs.

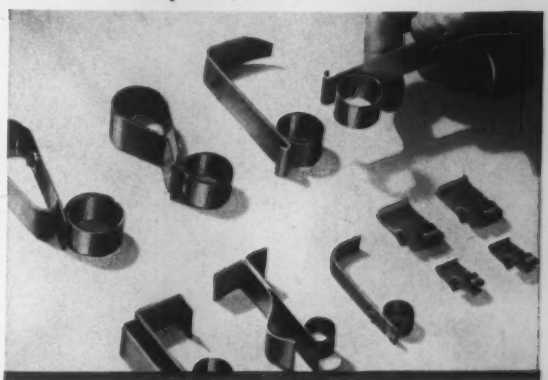


FIG. 1. Typical NEG'ATOR brush springs and holders.

From the Designer's Sketch Pad

300-INCH SLIDE RULE HAS SELF-COILING SCALES

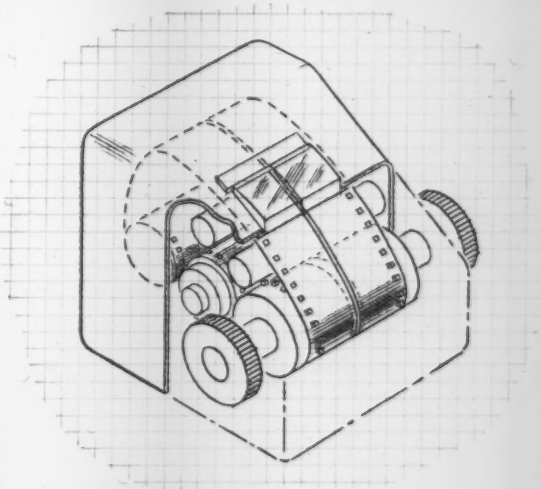


FIG. 3. NEG'ATOR tapes can provide great scale length in a small space. For instance, one alert inventor has patented a "desk-type" slide rule which provides 25 ft. of slide rule scales, accurate to 5 places, in a unit the size of a telephone. Because of the inherent NEG'ATOR characteristics of the two printed and perforated tapes, the ends tend to wrap around their respective storage bushings and are self coiling with equal force.

PUBLISHED BY HUNTER SPRING COMPANY • LANSDALE, PENNSYLVANIA

A Division of American Machine and Metals, Inc.

For an additional copy of this sketchbook Circle 440 on Page 19

(*Continued from reverse of this page*)

NEG'ATOR BRUSH SPRINGS . . .

On Small, Portable Generators

Using a NEG'ATOR brush spring, engineers at Winpower Manufacturing Co. designed a new brushholder assembly which cost considerably less than the previous one, was easier to assemble, simpler to service in the field, and gave better commutation. The holder now consists of a two-piece stamping as shown in Fig. 5. The previous holder consisted of a four-piece bronze casting which required machining and broaching.

The simple unit is comprised of two stainless steel NEG'ATOR springs, two brass stampings, a back plate, and the brushholder. The holder is mounted on the spider with machine screws and the springs and back plate are slipped into it. Tangs in the back plate engage detents in the holder and the reaction of the spring force against the carbon brush holds the unit in place. The spring exerts a constant .68 lb. force on the brush. No adjustment to compensate for brush wear is required.

Four of these assemblies are used in each lightweight, portable 1500 watt, 3600 rpm, 120 volt, a-c generator made by Winpower for military field service.

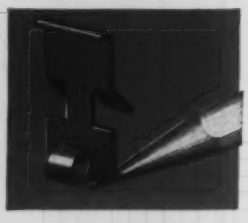


FIG. 4. Photo shows size of Winpower spring and back plate. Stainless steel springs are 3/16 in. wide. Maximum coil diameter is 1/4 inch.

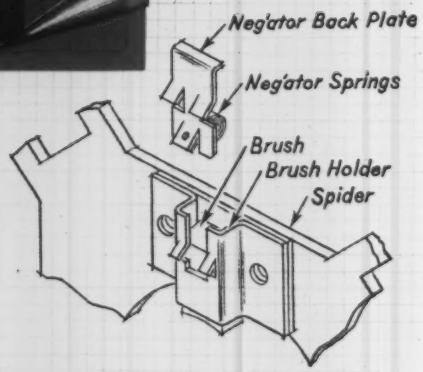


FIG. 5

On GE's KINAMATIC Line*

One of the many design features of General Electric Company's KINAMATIC d-c motors and generators is a brushholder which incorporates NEG'ATOR brush springs, see Fig. 6. Bulletins describing the KINAMATIC line state, "brush springs of new design permit changing of brushes with one hand. Springs maintain constant pressure throughout brush life."

FIG. 6

**KINAMATIC is a registered trademark of General Electric Company.*

STOCK SPIR'ATOR® MOTOR APPLIES ¾ POUND LOAD OVER 5 FEET

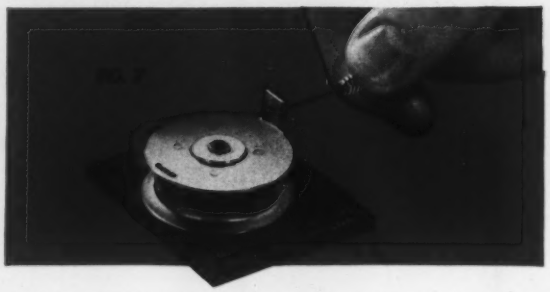


FIG. 7

A stock model of a SPIR'ATOR spring motor (a derivative of the NEG'ATOR motor) is now available from Hunter, see Fig. 7. This small mechanical motor will assist designers interested in applying this new mechanical drive element and should prove useful in actual applications requiring constant but small retracting forces over long deflections with minimum force buildup.

The motor is powered by a fully enclosed SPIR'ATOR spring, a spiral-type spring capable of producing a relatively constant output torque throughout long deflection. The outer rim of the spring case serves as a pulley for a stainless steel cable through which motor torque can be applied as a linear force. Maximum extension of the cable is 5 ft. and the force exerted on it by the spring varies from 12 oz. at full extension to 7 oz. when it is fully retracted. A bracket stops the cable in the normally retracted position and acts as a guide for the cable.

Mounted on a black plastic base the model motor assembly is 2 in. wide, 2⅜ in. long and 11/16 in. high. The unit sells for $6.50.

5 LB. CLAMPING FORCE MAINTAINED DESPITE EXPANSION AND CONTRACTION

NEG'ATOR clamps are formed by allowing a NEG'ATOR spring to form two coiled ends which exert "rated," equal force toward each other regardless of how far apart they are pulled.

One of several unusual features of the NEG'ATOR clamp is the fact that it need not be adjusted to compensate for expansion or contraction of the clamped material. Fig. 8 illustrates the usefulness of this characteristic.

In this application, two NEG'ATOR clamps are used to hold two pieces of a General Electric Co. plastic skillet handle together during cementing. The clamps are slipped around the handle by spreading the coils. As the cement dries and shrinks, the coils adjust automatically, compensating for the contraction. Each coil provides a clamping pressure of 5 pounds.

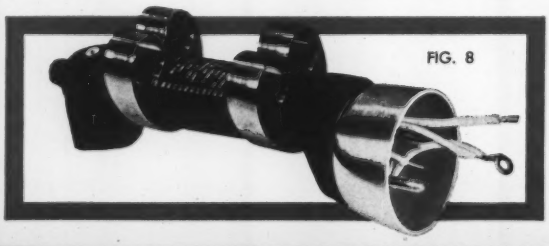
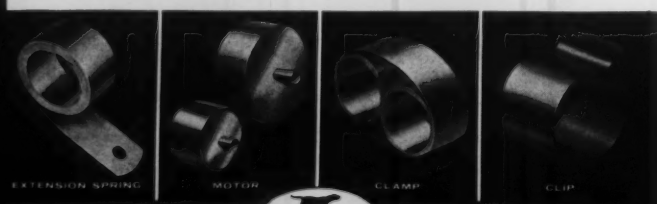


FIG. 8



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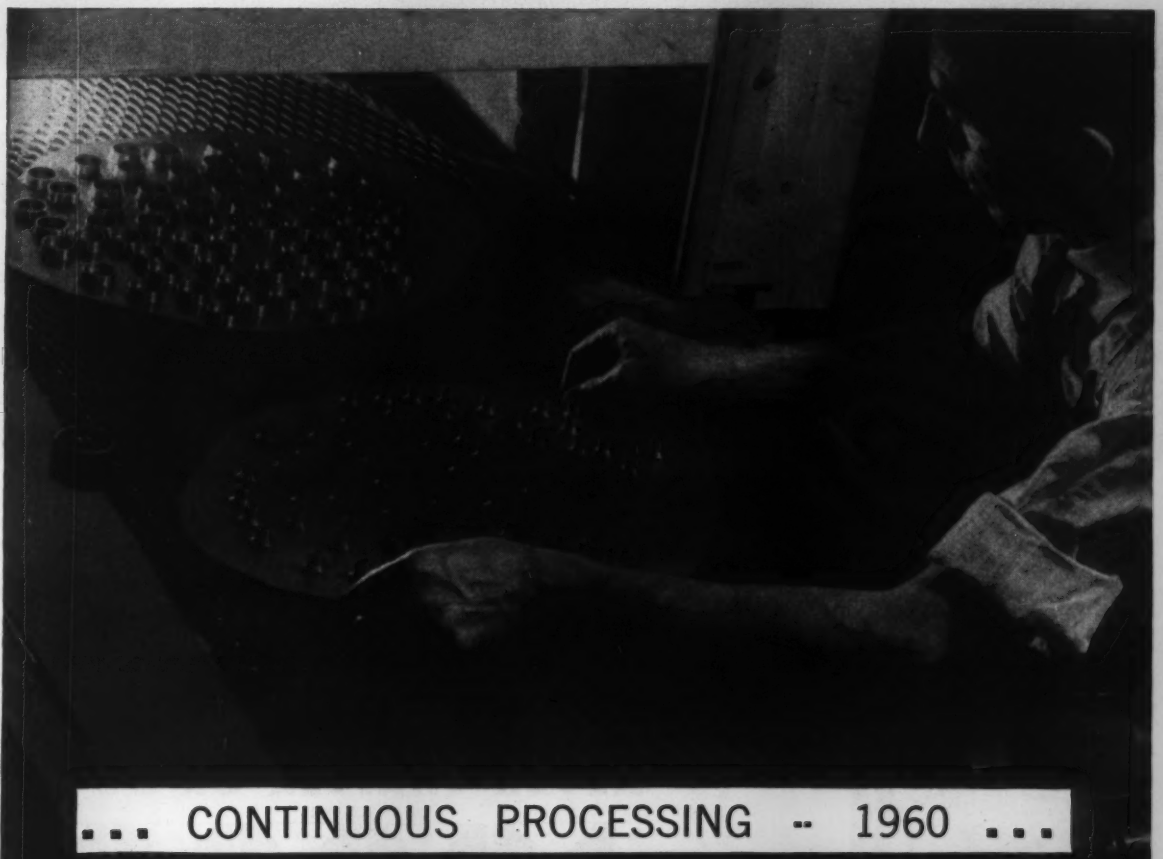

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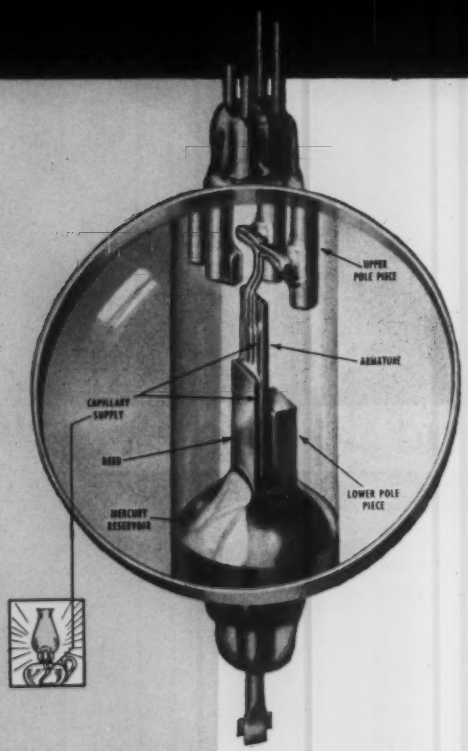
Over 8 billion* operations

C.L.A.R.E. Mercury-Wetted

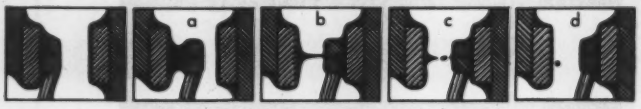
*with contact load of 250 volt-amperes.



NEVER WEAR OUT

Longevity is built into these relays. The basic magnetic switch is sealed in a glass capsule filled with pressurized hydrogen. With every make and break the mercury-film contact surface is renewed . . . by capillary action, like a lamp wick. These contacts never get dirty, never lock or weld and *NEVER WEAR OUT.*

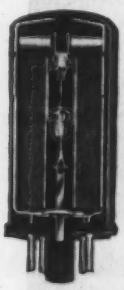
NEVER CHATTER OR BOUNCE



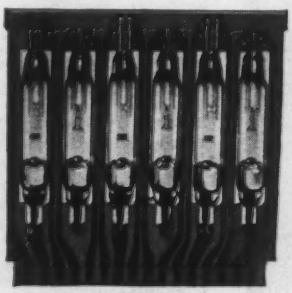
Contact closure between the two liquid surfaces bridges any mechanical chatter and prevents its appearing in the electrical output. (a) Filament of mercury forms between the contacts as they separate. (b) This becomes narrower in cross section and (c) finally parts at two points, allowing a globule of mercury to fall out. (d) The extremely fast break minimizes the arc and adds greatly to contact load capacity.

NO MAINTENANCE REQUIRED

HG Relay cutaway to show magnetic switch surrounded by operating coil and encased in a metal housing.



HGS Relay cutaway to show biasing magnets attached to the ends of the side plates.



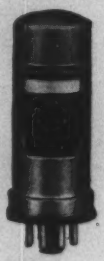
HG6F Relay printed circuit panel showing six in-line mercury-wetted contact switches mounted in minimum space.

With all working parts sealed and switches and coils enclosed in metal housings, these relays are tamper-proof and always in constant adjustment. They require no maintenance whatsoever.

–with no maintenance!

Contact Relays on test 4 years

A FULL LINE OF THE MOST RELIABLE, MOST DURABLE RELAYS EVER MADE

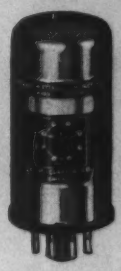


single form D

Type HG. Capable of up to 100 operations a second. Load-handling capacity to 5 amperes and up to 500 volts. (250 va max. with proper contact protection.)

single form D

Type HGP. Can be factory adjusted to provide single side-stable, bi-stable or chopper characteristics.



single form D

Type HGS. Biased with permanent magnets. Speed up to 200 cps. Sensitivity as low as ±2.5 milliwatts. Handles up to 2 amperes, up to 500 volts (100 va max. with proper contact protection.)

four form D

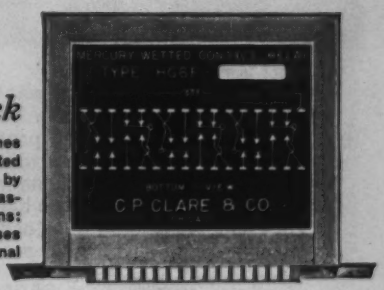
Type HG4. Four form D switches enclosed in a single housing with coil. Plug-in assembly (shown) is standard. Other mountings available.

two or three form D

Types HG2 and HG3. Two or three form D Switches enclosed in a single housing. HG2 has 8 or 11-pin octal style plug. An 11-pin base is standard for HG3.

six in-line flat pack

Type HG6F. Six switches mounted in line on printed circuit panel surrounded by single coil. Flat, compact assembly. Over-all dimensions: 3.640" x 3.125" x 1.046". Uses standard 32 or 36 terminal printed circuit socket.



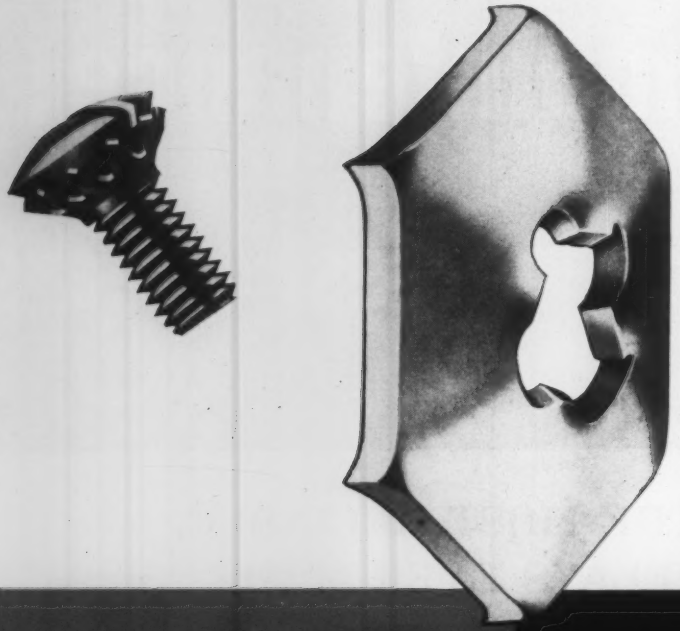
For complete information on CLARE Mercury-Wetted Contact Relays or on the entire CLARE line of superior relays and electronic components address: C. P. Clare & Co., 3101 Pratt Blvd., Chicago 45, Illinois. In Canada: C. P. Clare Limited, P. O. Box 73, 2700 Jane Street, Downsview, Ontario. Cable Address: CLARELAY.

Send for Catalog 201

CLARE RELAYS

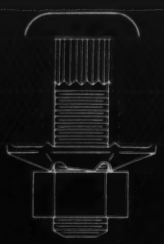
FIRST in the Industrial Field

Circle 442 on Page 19



HOW TO SELECT COST-SAVING

fasteners for heavy duty applications

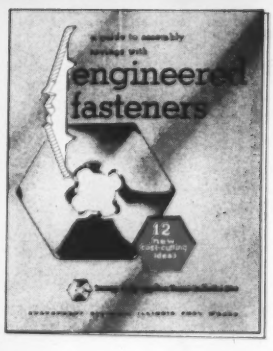


A TYPICAL EXAMPLE:
How to Fasten Securely to Avoid Shifting

Where considerable tension in the fastening is needed to keep the parts from shifting, the Shakeproof®-developed Pyramidal Lock Washer* should be used. This washer spans large clearance holes — provides tension needed to keep parts securely fastened and in alignment.

*U.S. Pat. No. 2,794,476

For want of the right fastener, man-hours and money are often needlessly lost! It's vital to economical assembly line production to specify fasteners for each application that will do a fast and effective job *every* time. Fasteners engineered by Shakeproof assure maximum locking, reduce handling, and provide many additional functions that save assembly time, reduce production costs and improve your product's quality.



SEND FOR NEW SHAKEPROOF BULLETIN NO. 200

Shows typical examples of money-saving fasteners developed by Shakeproof engineers for heavy metal applications. Offers testing samples. Write for your free copy today!

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St. Charles Road, Elgin, Illinois
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Division of Canada Illinois Tools Limited, 67 Scarsdale Road, Don Mills, Ontario

Circle 443 on Page 19

BOTH REDUCERS HAVE THE SAME CAPACITY!

This dramatic saving in weight and space is possible only because the reducer on the left has Philadelphia Precision Ground Gearing . . . a new development, so significant you can solve drive problems you could never solve before . . . because you get engineering advantages that have never been available before.

For the first time, standard commercial speed reducers are available with gearing of master gear quality. Extreme accuracy of profiles, profile spacing and surface finish reduce dynamic load factors. Harder gear materials can be used. Result: increased load carrying capacity without sacrificing performance characteristics.

Gear noise is reduced to the point where it is no longer a controlling factor in applications where low sound levels are important.

Backlash is reduced in reversing drives . . . and it is uniform where precision of movement is important.

Vibration is virtually eliminated because tooth to tooth errors, accumulated pitch errors and composite errors are reduced . . . smoother contact results.

Longer gear life. Improved accuracy and better surface finish eliminates "running-in" periods and the resulting wear on gearing.

If you have a new product on the boards . . . design changes coming up . . . or new drive requirements of any kind, Philadelphia Precision Gear Drives may give you the competitive edge you've been looking for. Write for full data on precision ground gearing in spiral bevel, parallel shaft and In-Line reducers as well as gearmotors and Motoreducers. If you have a special drive problem, the full facilities of our engineering staff are available to help you find the solution.

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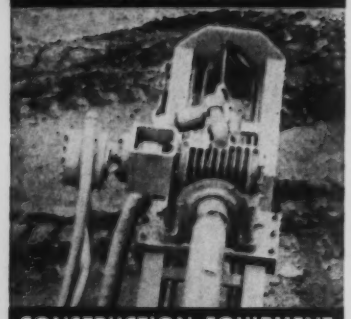
Offices in all Principal Cities • Virginia Gear & Machine Corp., Lynchburg, Va.
INDUSTRIAL GEARS & SPEED REDUCERS • LIMITORQUE VALVE CONTROLS • FLUID MIXERS • FLEXIBLE COUPLINGS

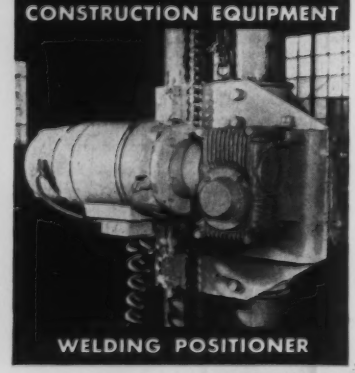
CONE-DRIVE WORM GEAR HOLLOW SHAFT SPEED REDUCERS

provide greater flexibility in the design of your equipment

MIXING MACHINE



CONSTRUCTION EQUIPMENT



WELDING POSITIONER

Standard Cone-Drive hollow shaft speed reducers are available in four basic sizes (2, 2½, 3 and 3½ inch center distance units) to accommodate loads from fractional to 13 horsepower. They are built around the double-enveloping worm gear design and carry the same high ratings as standard Cone-Drive speed reducers.

You, as a designer, will be particularly interested in the versatility of application and space savings made possible by the right angle design between input and output shafts.

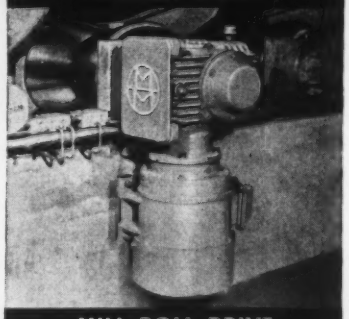
The reducer is mounted directly on the driven shaft and requires only a simple bracket or torque arm to prevent it from rotating about the driven shaft.

Construction is rugged enough to permit floor or wall mounting of Cone-Drive hollow shaft reducers and "hanging" the driven shaft on it (in certain applications), eliminating pillow blocks or bearings. Larger-than-necessary taper roller bearings and heavy-duty castings make this possible.

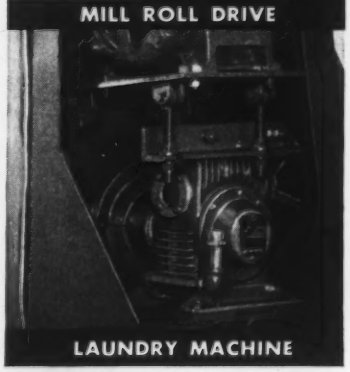
If a motorized reducer is desired, a simple, standard bell housing can be furnished for NEMA C-type face motors. The need for expensive couplings is eliminated since a tang-type drive sleeve and suitably machined worms are provided. When a hollow-shaft speed reducer and face-mounted motor are combined, no bed plate or mounting arrangement is required. Pulleys, belts, sheaves, etc., that might be troublesome or difficult to install are also eliminated.

Ask for Bulletin CD-218.

TROLLEY HOIST



MILL ROLL DRIVE



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DOUBLE-ENVELOPING WORM GEARSETS

DOUBLE-ENVELOPING WORM GEAR SPEED REDUCERS

DOUBLE REDUCTION WORM GEAR SPEED REDUCERS

DOUBLE-ENVELOPING RIGHT ANGLE GEARMOTORS

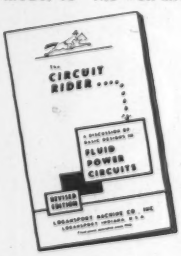
Illustrated—Logan Model 400 RFL Unit

Look to Logan

the ultimate in air circuit accessories

Logan RFL Unit, the designers choice for over a decade! Protects your air-powered equipment . . . regulates pressure . . . filters air . . . lubricates air. Adds years of dependable performance.

New Model 400, illustrated above, is a companion model to the well-known Model 600.



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Circle 446 on Page 19

ARE YOU SURE YOU NEED AN EXPENSIVE "SPECIAL" MOTOR?

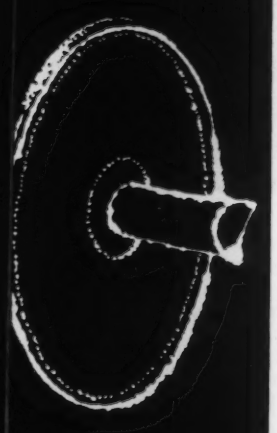
INEXPENSIVE WESTINGHOUSE STANDARD MOTORS HAVE BEEN DOING "SPECIAL" JOBS FOR YEARS!

Sometimes you have to use a "special" motor. But *not usually!*

Even though your application is a "special" one, the chances are excellent that you can apply a *Westinghouse standard* fhp motor without a loss in efficiency, appearance or output—and at a much lower cost.

Bear in mind, too, that Westinghouse engineers build the *Westinghouse standard* motor to the very top of NEMA specifications—your assurance of super-standard performance!

Here are some other concrete examples of the advantages of using *Westinghouse standard* motors:



LOWER PRICE! . . . of course.

LESS ASSEMBLY TIME! . . . on your production line.

NO REPLACEMENT PROBLEMS! . . . for your customers.

REPAIR FACILITIES! . . . on almost every corner.

SURE DELIVERIES! . . . right from the shelf.

LOWER PRICE! . . . we said that, but it bears repeating.

Call in your local Westinghouse sales engineer today and ask him to look over your fhp motor application. It's a good bet that all you're getting with your present "special" motor is a "special" (higher) price.

Or write: Westinghouse Electric Corporation, Mr. D. J. Maxwell, Industrial Motor Department, Lima, Ohio.

Westinghouse offers a full line of completely *standard* 48- and 56-frame motors—"specially" designed to the top limits of NEMA specifications! J-03926

YOU CAN BE SURE...IF IT'S

Westinghouse

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Circle 447 on Page 19

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Shell Macoma Oils are available world-wide . . . assurance that your customers abroad will get the same performance from your equipment that your domestic customers rely upon.

Macoma® Oils are premium quality, fortified extreme pressure industrial gear oils. They provide superior high-load-carrying capacity and are particularly effective where overloading, severe shock-loading or general heavy-duty conditions exist.

Macoma Oils have these added built-in benefits: excellent resistance to oxidation, great adhesiveness, rapid separation from water. They are non-corrosive, non-foaming and have high stability in storage.

For more information, write Shell Oil Company, 50 West 50th Street, New York 20, New York, or 100 Bush Street, San Francisco 6, California. In Canada: Shell Oil Company of Canada, Limited, 505 University Avenue, Toronto 2, Ontario.

SHELL MACOMA OIL

the extreme pressure industrial gear lubricant

SHELL

PRESSURETROL*
PRESSURE CONTROLLERS

Here are new additions to Honeywell's broad line of pressure switches designed specifically for industrial use. Use them for reliable, economical control of liquid or gas pressure—alone as controllers, or with other instruments for limit alarm or signalling service.

1. MODELS P428A, B, C, D FOR CONTROL OF PRESSURES TO 3000 PSI

These *Pressuretrols* consist of a single-pole, single-throw mercury switch operated by a corrosion-resistant Bourdon tube. The case is designed to harmonize with other instruments, and is ideal for use in panels. It is compact, of drawn steel with a die-cast cover, and resists dust, weather and corrosion. The *Pressuretrol* can be surface or flush mounted on a panel or installed directly on a pipe. Pressure settings are made with two knobs conveniently located on the face of the unit.

SPECIFICATIONS

MODELS: P428A, standard case, spst, breaks circuit on pressure rise.
P428B, standard case, spst, breaks circuit on pressure fall.
P428C, explosion proof, spst, breaks circuit on pressure rise.
P428D, explosion proof, spst, breaks circuit on pressure fall.

Pressure Ranges	Maximum Pressures	Bourdon Tube
30— 300 psi	375	Bronze or stainless steel
50— 600 psi	750	Bronze or stainless steel
100—1000 psi	1200	Beryllium copper or stainless steel
200—2000 psi	2400	Beryllium copper or stainless steel
300—3000 psi	3500	Beryllium copper or stainless steel

2. MODELS P444A, B FOR INDEPENDENT HIGH AND LOW PRESSURE SETTINGS

Use these *Pressuretrols* in a wide variety of industrial applications that call for independent high and low pressure settings and switching action. A pressure-actuated, corrosion-resistant stainless steel diaphragm positions a mercury switch according to selected pressure settings. The mercury switch, scale plate and pressure setting indicators can be easily seen through a protective glass window in the cover. Pressure setting handwheels extend through slots in the cover. Adaptable for either surface or flush mounting.

SPECIFICATIONS

MODELS: P444A, standard case, spst, breaks circuit on pressure rise.
P444B, standard case, spst, completes circuit on pressure rise.

Range	Maximum Pressure
20" vac.—40 psi	75 psi
1—20 psi	50 psi
5—60 psi	80 psi
5—150 psi	200 psi

Get complete details from your nearby Honeywell field engineer. Call him today . . . he's as near as your phone.

MINNEAPOLIS-HONEYWELL, Wayne and Windrim Avenues, Philadelphia 44, Pa.

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H HONEYWELL First in Control

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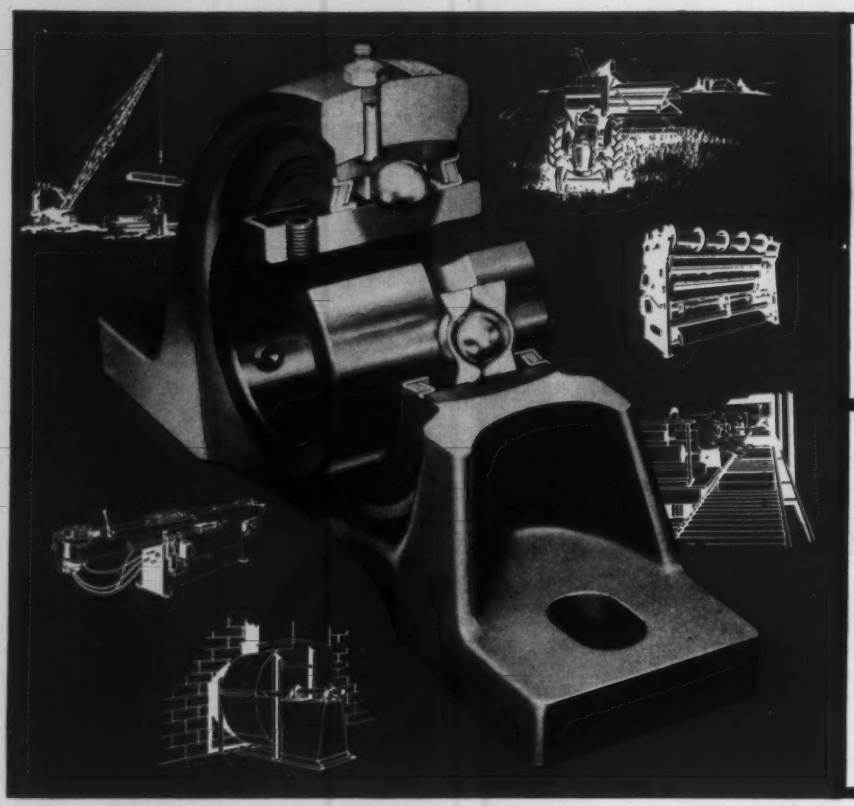
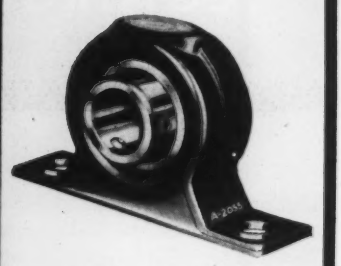


"LP" PILLOW BLOCK



RUBBER MOUNTED PILLOW BLOCK

SEALMASTER®

...quality that builds acceptance!

There is no greater assurance of performance than quality. SEALMASTER gives you that quality in a complete line of ball bearing units, providing a wide range of mountings in shaft sizes from ½" to 4 15/16".

Patented SEALMASTER "Zone Hardening" affords simplified, secure locking to shaft. One piece housings eliminate loose pieces that increase your assembly costs. And when cost is a primary requisite there's no need to sacrifice quality.

The new SEALMASTER "L" Series provides a precision, low-cost line of self-aligning ball bearing units. They are permanently sealed and pre-lubricated with a high grade lubricant for long life.

SEALMASTER rubber mounted units provide extremely quiet operation where noise is an important factor.

Whatever you look for in a bearing unit — quality — performance — economy — there's nothing comparable with SEALMASTER!

WRITE FOR CATALOG 454.

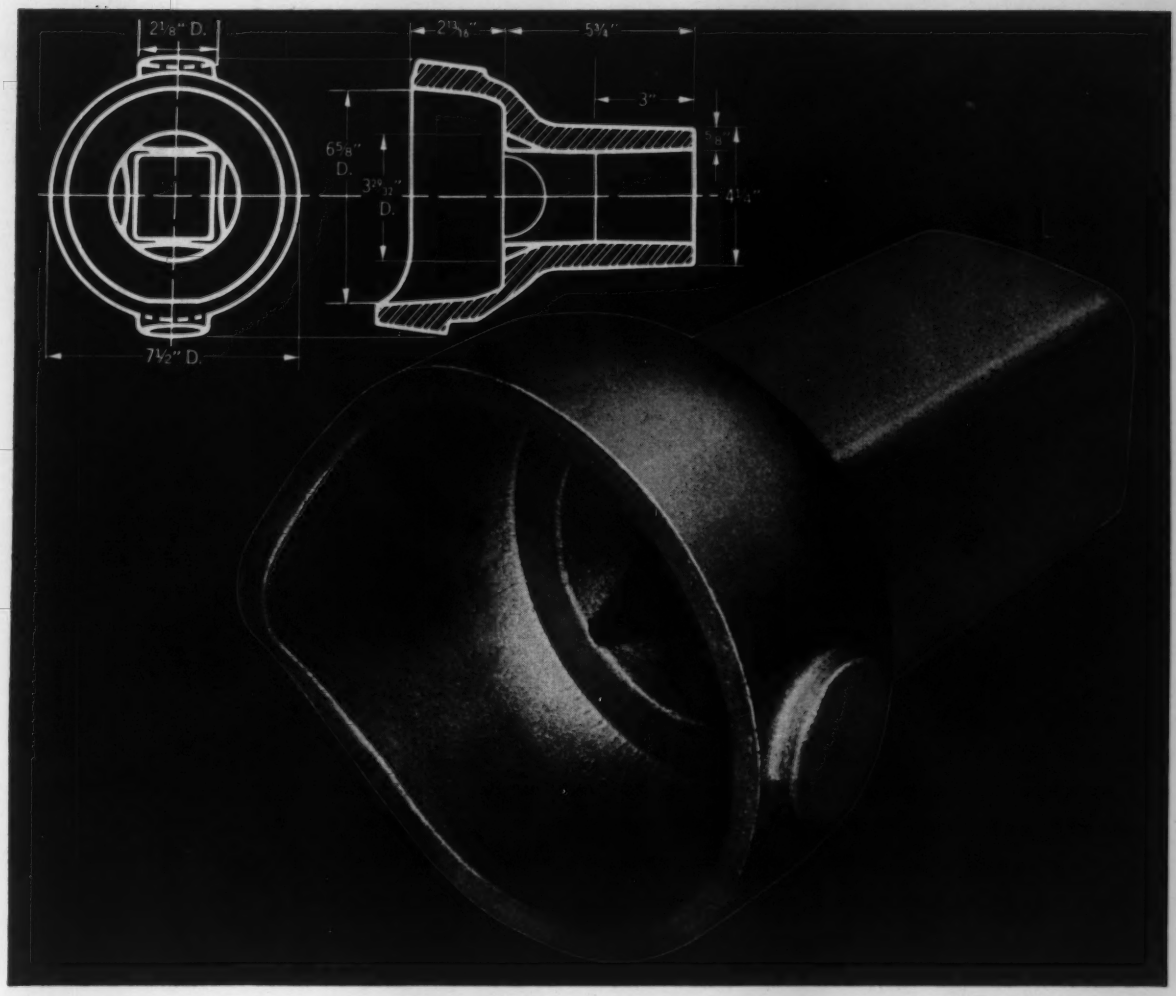
SEALMASTER® BALL BEARING UNITS

SEALMASTER BEARINGS

A DIVISION OF

STEPHENS-ADAMSON MFG. CO.

18 RIDGEWAY AVE., AURORA, ILL.



Odd Shape...Natural for Casting?

Look how "Task-Forging" improved strength, reduced cost!

Once cast in steel, this front axle trunnion socket is now forged by COMMERCIAL on an 8" upsetter from 3¾" diameter SAE 1040 bar stock. Result: Costly excess machining and waste stock is eliminated by internal and external displacement of metal to only the points where it is needed for greatest efficiency.

Notice the open rectangular end, the angularity at the open belled end, the increased metal thickness at the bosses, and their eccentric center line position. Such an odd shape is seldom considered as an upset forging, yet to the COMMERCIAL "Task-Forging" team, with years-ahead pioneering in specialized techniques and equipment, upsetting the large stock displacement to + 0, −1/16" internally and + 1/16", − 0 externally was routine.

The improved strength and efficiency of this part is a direct contribution of COMMERCIAL "Task-Forging"... a complete service offering research, testing and design assistance to manufacturers seeking stronger, more compact component parts at less cost. Backed by modern, highly advanced upsetting facilities, the COMMERCIAL "Task-Forging" team is producing unusually complicated shapes with flexibility closely approaching the casting process while retaining the inherent strength and material integrity of forgings.

Please feel free to avail yourself of COMMERCIAL's "Task-Forging" service, without obligation. Just send a blueprint or sketch of your unusual or difficult part... existing or planned. With 30 years of specialization in "tough" metal forming problems, and equipment "designed-by-experience" to handle them, COMMERCIAL engineers may well be able to help you. Write to Commercial Shearing & Stamping Company, Dept S-42. Youngstown 1, Ohio.

COMMERCIAL
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GRAMIX® COMPRESSOR BODY

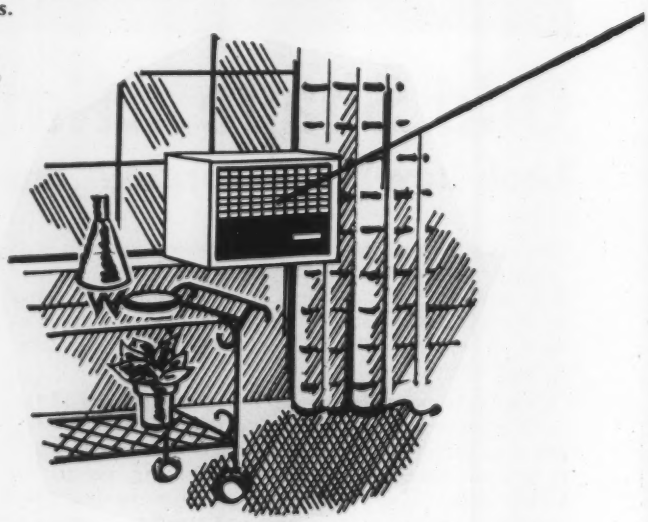
GENERAL ELECTRIC AIR CONDITIONER

this GRAMIX part is a new concept in powder metallurgy techniques . . . engineered to meet requirements of GENERAL ELECTRIC'S new compressor design

This large, complex shaped compressor body which is employed in air conditioners manufactured by General Electric is an outstanding example of a GRAMIX part engineered and produced to exacting specifications. As in all GRAMIX products of powder metallurgy, the alloy was created to meet exacting physical properties required in this particular application. Correct briquetting, controlled sintering procedures, precise finishing operations and rigid quality control throughout the manufacturing process assures General Electric uniform, dependable GRAMIX parts. The production of this body as a product of powder metallurgy has also enabled General Electric to effect important design changes in their air conditioning units.

GRAMIX engineers have the experience, the techniques and the equipment to produce top quality products of powder metallurgy. No matter what type of part you need, no matter what characteristics that part must possess, it will pay you to select GRAMIX . . . and get both "job-engineered" alloys and quality-controlled production to meet each specific operating requirement.

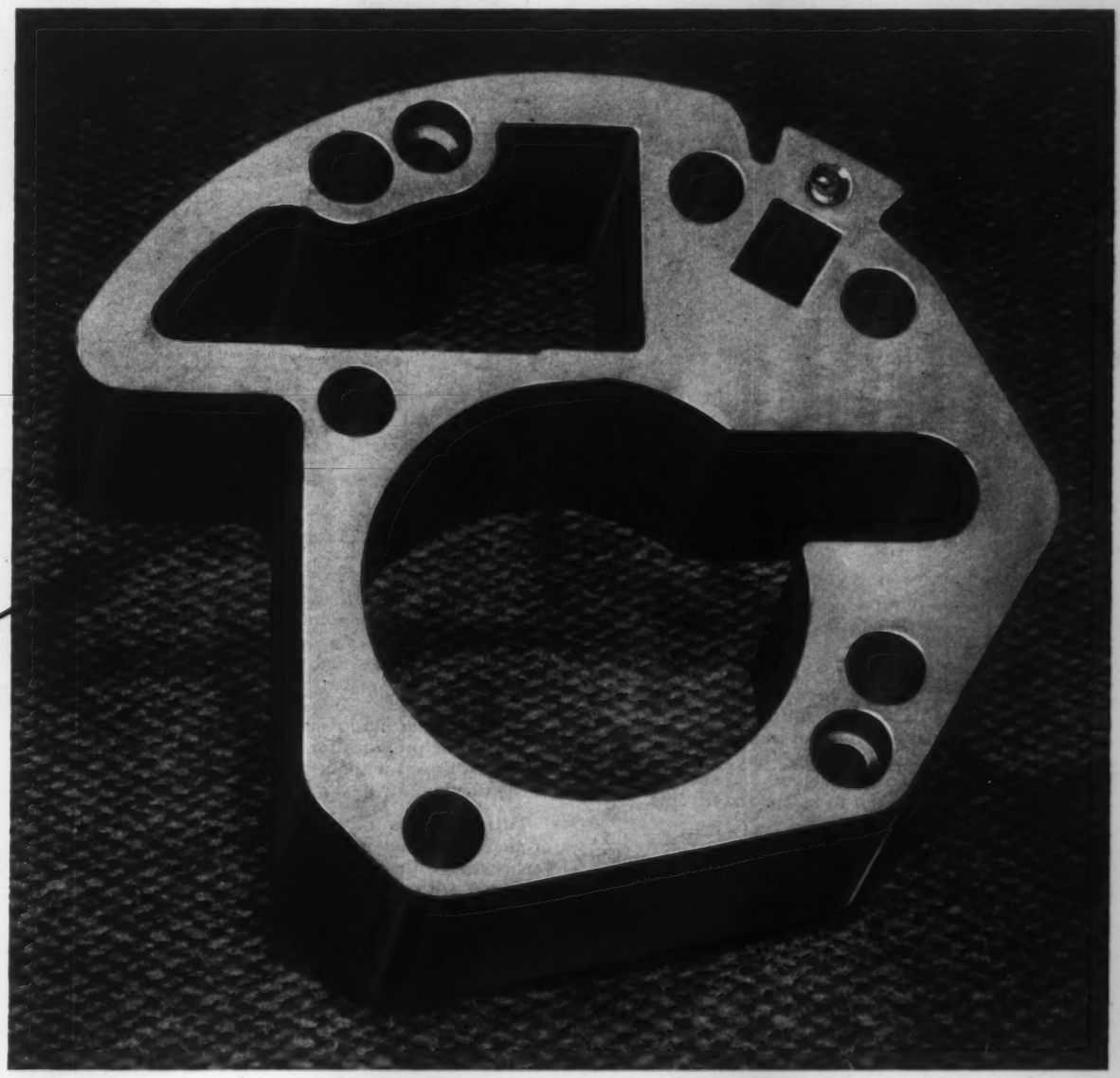
◀ **Write today for these helpful engineering manuals. No. 18 covers design and metallurgical requirements and alloy selection of GRAMIX bearings. No. 19 covers GRAMIX Machine Parts and No. 21 contains general information on GRAMIX products from Powder Metallurgy.**



THE UNITED STATES

GRAPHITAR® CARBON-GRAPHITE • **GRAMIX®** POWDER METALLURGY • **MEXICAN®** GRAPHITE PRODUCTS • **USG®** BRUSHES

IS VITAL PART IN

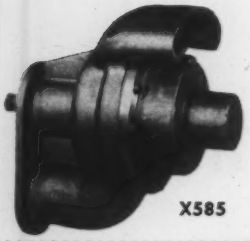


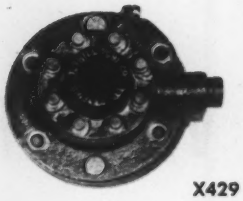
This part is shown 1½ times size. Actual weight: 2¼ lbs. X-271-2

GRAPHITE COMPANY

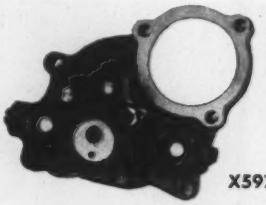
DIVISION OF THE WICKES CORPORATION, SAGINAW 7, MICHIGAN

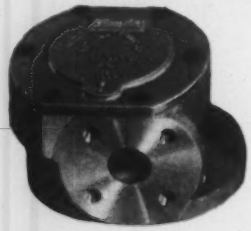
X250

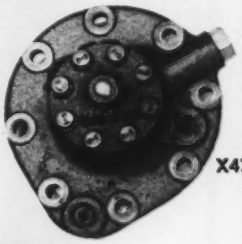

X585


X429

LDK


X597


X543


X476

for those special applications . . .

TUTHILL fits the pump to the PROBLEM

Here you see seven pumps . . . each designed to provide the best possible answer to one specific problem. They are typical of the many special application pumps developed each year at Tuthill.

For, while Tuthill offers over 800 standard models, often a customer's particular requirements indicate the desirability of special features not included in the standard line. For these applications Tuthill attempts to develop a pump to fit the problem . . . not require the user to modify his problem to fit a standard line.

Special housings

The seven examples shown indicate Tuthill's versatility in developing special housings for different types of equipment. For example, number X250 above was designed to provide a pump for a hydraulic actuator on a machine tool. The most convenient place to install this pump was on the hydraulic column . . . so the special mounting shown was designed. Most of the other unusual shapes shown above were similarly devised for greater convenience and lower assembly costs in building a pump into a particular piece of equipment.

Special materials, shafts, gearings

This versatility of housings and mounting arrangements only begins to indicate Tuthill's ability to best meet the requirements of a given application. As another example, models number X543 and X585 have bronze outer construction, and other features which particularly qualify them for marine applications. Model X429 above incorporates Tuthill's special automatic reversing feature. This means the pump may be driven from a reversing shaft . . . or provides for applications where a machine must be shipped without knowing the ultimate direction of the driving unit.

Tuthill pumps may be supplied with a wide variety of shaft seals for use with various fluids. They can incorporate strainers, as model X585 above. They may be provided with, or without, built-in relief valves. They can incorporate a wide variety of special shaft modifications or gearing to accommodate various driving units.

They may be provided with steam jackets for use with viscous fluids. They may be also shipped as stripped models that can be built right into your equipment.

Tuthill's experienced application engineers will be happy to show you how Tuthill can develop a pump to fit the requirements of your particular application. Write today for a copy of catalog 100.

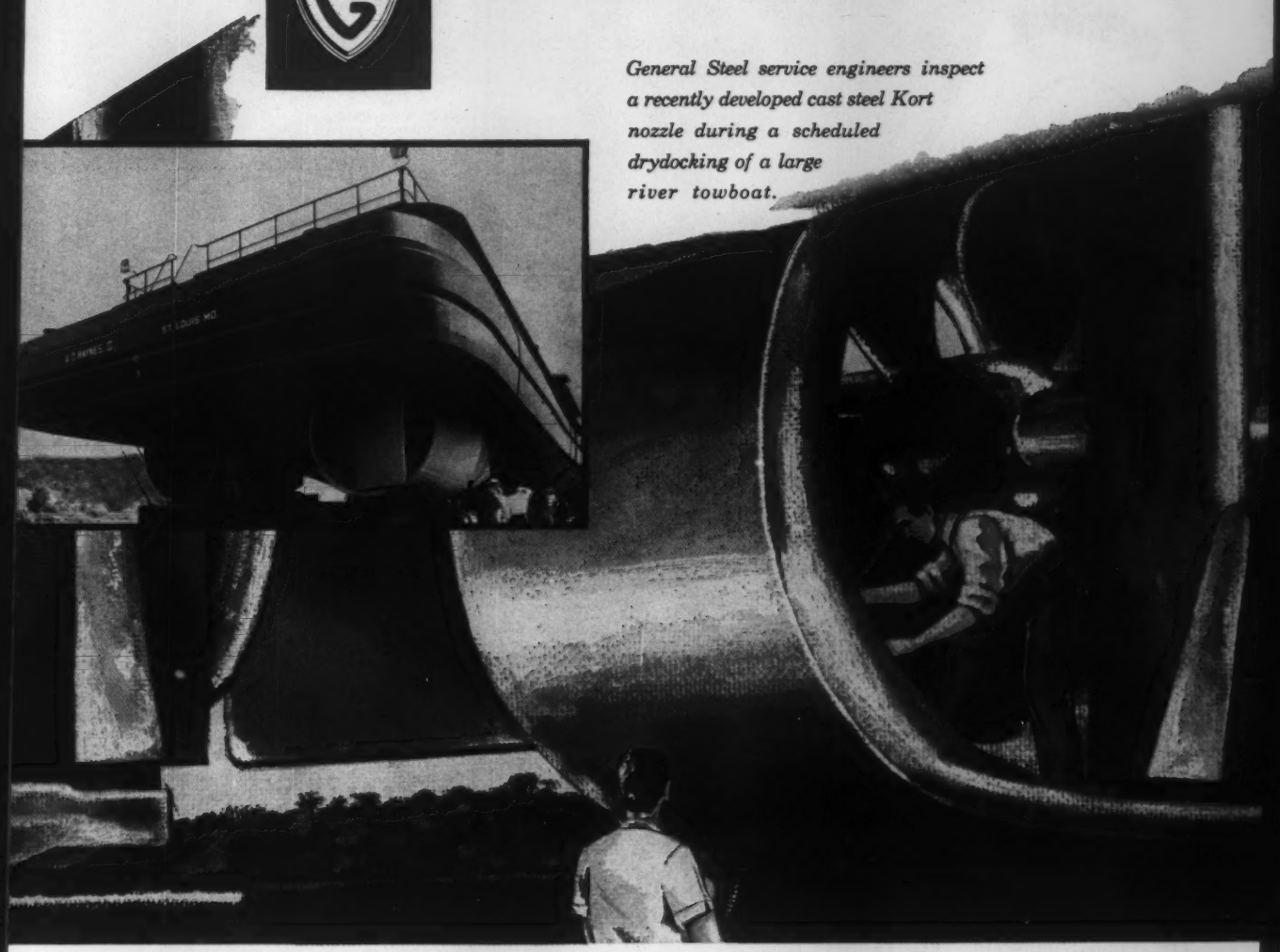
Tuthill manufactures a complete line of positive placement rotary pumps in capacities from 1 to 200 GPM; for pressures to 1500 PSI; speeds to 3600 RPM.

TUTHILL PUMP COMPANY

953 East 95th Street, Chicago 19, Illinois

Circle 453 on Page 19

...where industrial progress is cast in steel



General Steel service engineers inspect a recently developed cast steel Kort nozzle during a scheduled drydocking of a large river towboat.

FIELD SERVICE...PERSONALIZED PRODUCT ATTENTION

Attention to detail . . . inspection in the plant . . . assistance with assembly . . . inspection again while in use . . . and most important of all, service when you need it . . . these are all parts of General Steel's complete service.

When unpredictable events occur, General Steel service engineers are available to you to help return your units to service with minimum delay.

Representatives from every department . . . engineering, manufacturing, sales . . . are available to work closely with you from concept—to casting—to completed product. Let us show you the benefits of this integrated service in helping you plan components of your products . . . in cast steel, cast weld or composite structures.

Write for folder **How General Steel Castings Can Improve Product Design and Performance.** General Steel Castings, Station 260 Granite City, Illinois

GENERAL STEEL CASTINGS

GRANITE CITY, ILL. • KEYSTONE, PA. • AVONMORE, PA.

Circle 454 on Page 19

YOU SHOULD TRY ELECTRUNITE

The welded hydraulic fluid line tubing that offers lower initial cost... appreciable savings in downtime

The reason... uniformity! ELECTRUNITE Hydraulic Fluid Line Tubing is made from *high-grade, close-tolerance, flat-rolled* steel. Checked for defects as only flat rolled steel can be checked. Then: carefully formed, welded, annealed, cold-worked, and annealed again into a tube of unsurpassed uniformity... a tube that is easier to bend, easier to flare... a tube that meets or exceeds the normal life of tubing produced by any other method.

All this plus the fact that ELECTRUNITE costs *less* to buy (in all sizes shown in the *JIC Standards Book* and in an even wider range of sizes produced to our specification HL-1). Savings in downtime reflect still greater cost reductions. In the history of ELECTRUNITE Hydraulic Fluid Line Tubing, no failure resulting from longitudinal or transverse cracks has been reported.

The big switch is on! Join the hundreds of equipment and machinery builders and their maintenance departments now using millions of feet of ELECTRUNITE Hydraulic Fluid Line Tubing. Mail the coupon for complete information, including a copy of specifications.

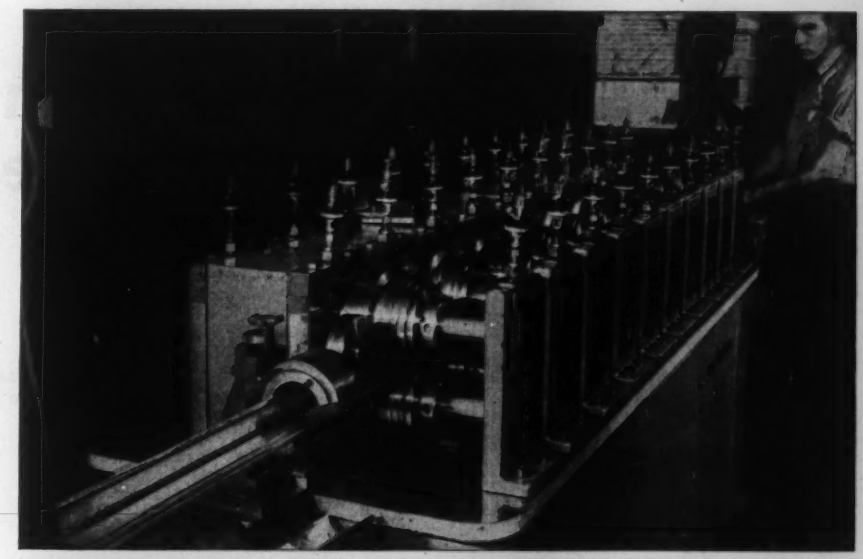
MEETS ALL REQUIREMENTS OF THE JIC STANDARD!

ELECTRUNITE® is available in all sizes shown in JIC Standards Book. Available in a wider range of sizes produced to our specification HL-1 (which meets all test requirements of the JIC standard).

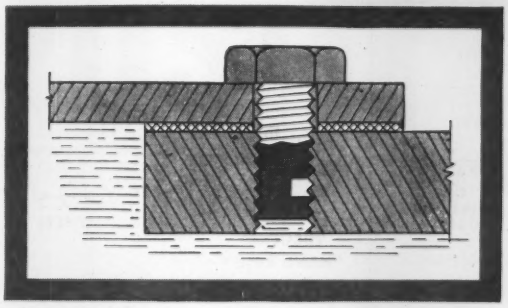
REPUBLIC

World's Widest Range of Standard Steels and

SAVE PAINT PREPARATION COSTS on your formed steel products by specifying Republic Electro Paintlok®. Special paint-holding surface applied at our mills won't crack, flake, or peel—even under severe bending—as demonstrated by this acoustical panel forming operation. Final finish can be applied immediately, with excellent results. Mail coupon for complete information.



ELIMINATE PRODUCTION BOTTLENECKS with Berger Division contract manufacturing facilities. You get the benefit of complete cost and quality control, extensive facilities, and a wealth of sheet steel fabricating experience. Investigate this means of assuring high-quality products or components while reducing plant and tooling investment. Return the coupon for complete information without obligation.



LIQUID SEALING PERFORMANCE is an added feature with Republic Self-Locking Nylok® Bolts. Nylon Pellet in compression tends to expand, effectively closing the space between non-loadbearing surfaces of mating threads. Fluid escape along helical thread path is blocked. Nylon pellet resists aging, moisture, and ordinary solvents. Send coupon for full information.

STEEL

Steel Products

REPUBLIC STEEL

REPUBLIC STEEL CORPORATION
DEPT. MD-8084-A
1441 REPUBLIC BUILDING • CLEVELAND 1, OHIO

Please send more information on:

- ☐ ELECTRUNITE Hydraulic Fluid Line Tubing, including a copy of specifications
- ☐ Self-Locking Nylok Bolts
- ☐ Berger Division Contract Facilities
- ☐ Republic Electro Paintlok

Name_____ Title_____

Firm_____

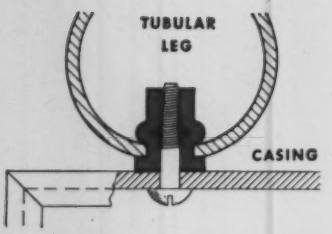
Address_____

City_____ Zone____ State_____

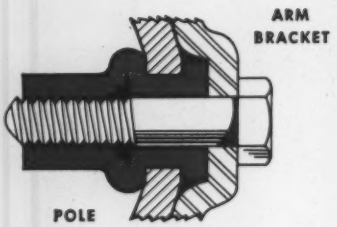
Circle 455 on Page 19

B.F.Goodrich

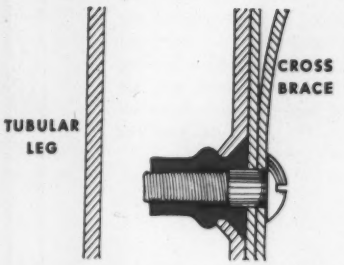
Only B. F. Goodrich Rivnuts® solve all these fastening problems so well



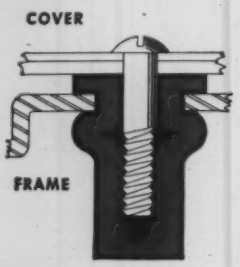
One man installs Rivnuts from one side in seconds—speeds assembly of *barbecues*. Permanent nutplates in legs save time in faster knockdown, too.



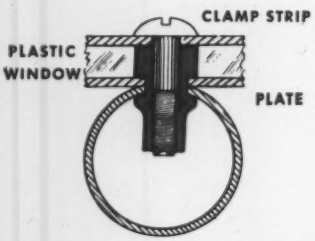
One man does the work of two, assembling arm brackets on *light poles*. Tests show pole or arm will fail before Rivnuts.



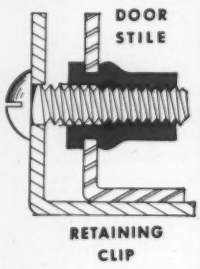
Clean, functional lines of modern *furniture* are preserved by Rivnuts. Upset inside tubular legs, they replace unsightly nuts, bolts and screws.



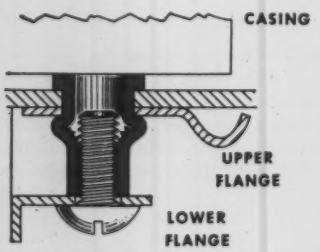
Rivnuts enable repair men to remove top of *automatic washer* and replace it easily. And Rivnuts can be installed after enamelling.



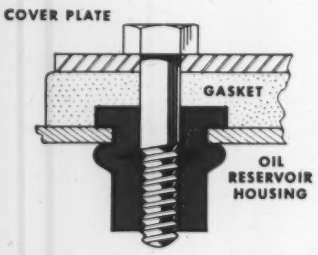
Upset Rivnuts secure *airplane window* plate to center post. Bulges in shanks seal out weather. Heads of Rivnuts serve as spacers for plastic window.



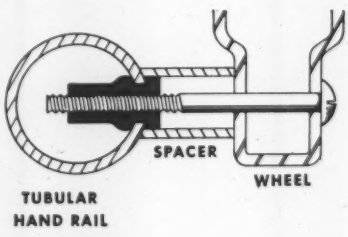
Rivnuts replace self-tapping screws used to hold retaining clips on aluminum *storm doors*, provide firm nutplates that won't loosen with shock or vibration.



Rivnuts eliminate need for reinforcing plates in *vaporizers*. In addition, Rivnuts space bottom flange automatically, prevent bending.



Assembly time for *oil reservoirs* is cut in half. Rivnuts eliminate welding, tapping and cleaning previously required to attach coverplate.



Wheel chair designers needed a blind nutplate with at least 6 clean threads. Rivnuts, only one-piece blind rivets with threads, were the answer.

Special fastening problems? B. F. Goodrich Rivnuts solve them. Send for free data book. Dept. MD-109, B. F. Goodrich Aviation Products, a division of The B. F. Goodrich Company, Akron, Ohio.

B.F.Goodrich *aviation products*

FAMOUS QD HUB
with its 2 Golden Screws. The clamp screw simplifies installation and assures permanent alignment. The set screw prevents "key drift."
PULLEYS*
positive
drive
BELTS

Worthington Introduces

POSITIVE DRIVES

newest concept in power transmission with advantages of both chain and belt

Positive Drive is the newest concept in mechanical power transmission. It makes possible savings in weight, space and bearing size without the sacrifice of efficiency. Amazingly versatile, Positive Drives can be used for applications from fractional up to 600 hp and speeds from 100 to 10,000 rpm.

Some of the many benefits of this new drive include:

- Increased productivity
- No stretch
- Low tension
- No backlash
- No lubrication
- Lightweight
- Quiet
- No vibration
- Compact
- Wide speed range
- Wide horsepower range
- Synchronization
- High mechanical efficiency
- Easy installation

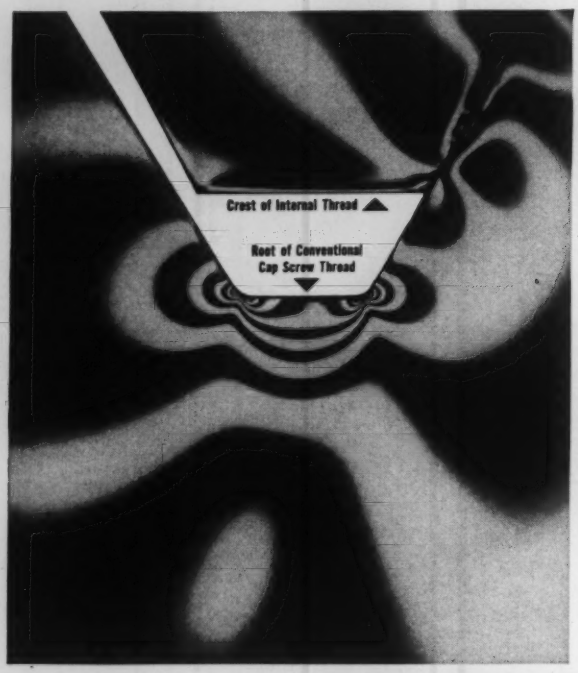
WORTHINGTON

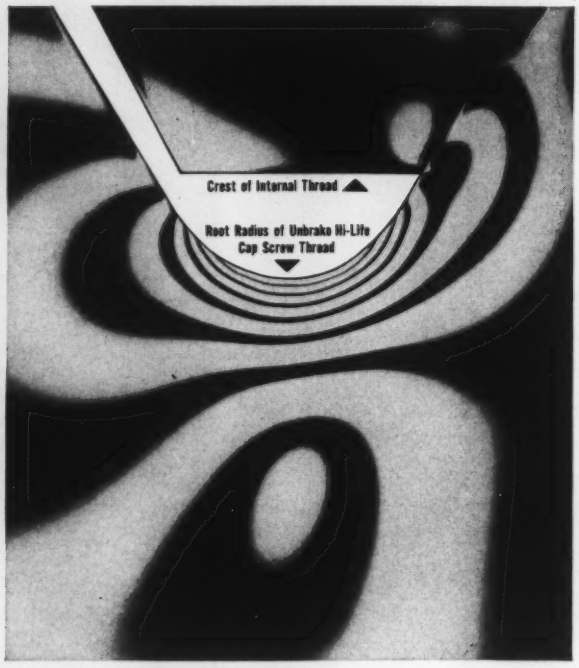
Want more facts? Write for your copy of a 64-page Positive Drive Manual. Address Worthington Corporation, Section 79-24, Oil City, Pa. Ask for Bulletin 7950-B3. In Canada: Worthington (Canada) Ltd., Brantford, Ont.

*T.M. The Goodyear Tire & Rubber Co.

SPS RELIABILITY / *A dynamic standard of predictable performance*

The big change is in the threads





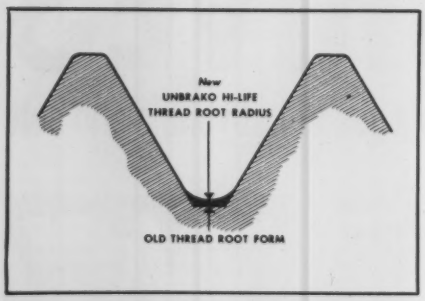
COMPARE THESE PHOTOELASTIC STUDIES

OLD THREAD ROOT FORM has sharp corners which cause high stress concentration and reduce fastener fatigue life.

NEW UNBRAKO HI-LIFE THREAD ROOT has large, smooth radius which distributes stresses, thereby increasing fastener fatigue life.

At no increase in cost, new UNBRAKO Hi-Life socket head cap screws offer

- **Up to 100% greater fatigue life**
- **Increased tensile strength capacity**
- **Additional life insurance for your product**



COMPARE THE THREAD ROOT FORMS in the drawing at left. The bottom line indicates the old thread root form. Note the flat roots with sharp corners where cracks start. The top line indicates the new thread root form of UNBRAKO Hi-Life socket cap screws. Note the smooth, flowing curve that dissipates stresses. In addition to increasing fastener fatigue life up to 100%, the larger body cross section provides greater tensile strength, permitting the application of greater preloads.

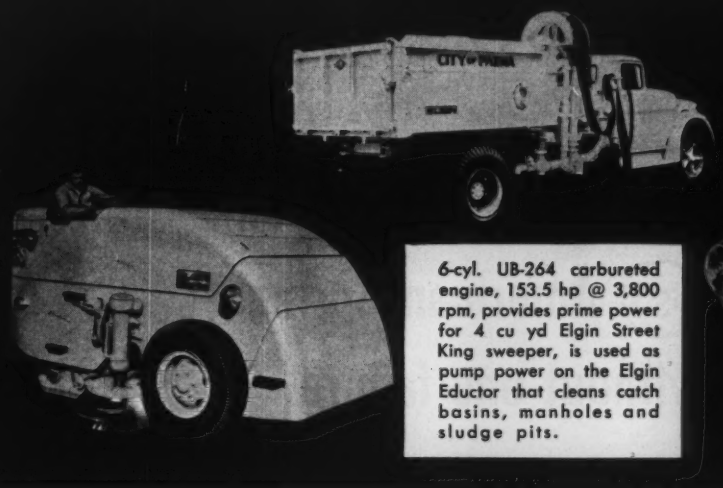
And there is no waiting for the bonuses you get from new UNBRAKO Hi-Life socket cap screws. SPS distributors are now stocking these new precision fasteners with the improved thread root form, evolved through research on high-strength fasteners. Fatigue life of improved UNBRAKOS can increase the reliability of your product.

For more information, ask your nearest authorized SPS industrial distributor for a copy of Bulletin 2577. Or write SPS—manufacturer of precision threaded industrial fasteners and allied products in many metals, including titanium.

INDUSTRIAL FASTENER Division SPS

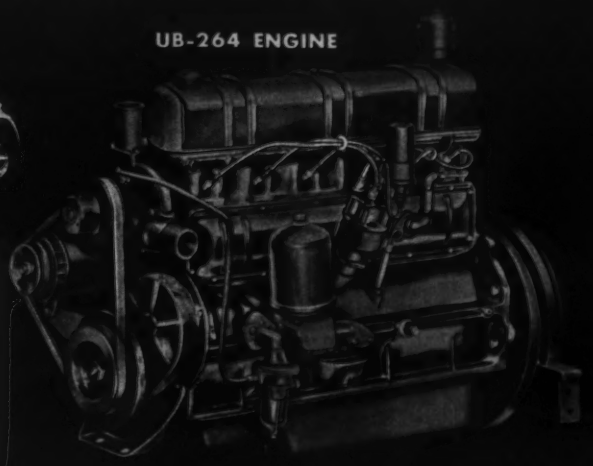
JENKINTOWN 18, PENNSYLVANIA

Circle 458 on Page 19



6-cyl. UB-264 carbureted engine, 153.5 hp @ 3,800 rpm, provides prime power for 4 cu yd Elgin Street King sweeper, is used as pump power on the Elgin Eductor that cleans catch basins, manholes and sludge pits.

UB-264 ENGINE



Why Elgin Sweeper Company specifies International power in 3 products

Robert Schmidt, Chief Engineer, Elgin Sweeper Co.

Robert Schmidt, Chief Engineer, Elgin Sweeper Company, specifies International 6-cylinder carbureted engines 100% for the three Elgin products shown here, and he gives these reasons why:

"We selected International BD-240 and UB-264 engines for our requirements because we needed heavy duty engines with superior sealing that would keep working under extremely dusty conditions.

"Our customers tell us these International engines keep our machines operating whenever there's work to be done, and they like the availability of International parts and service to be found in both small and large communities."

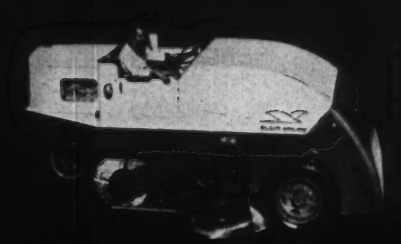
When your next products advance to the design stage, check into the complete International engine line—14 carbureted models, 10 diesels with a power range of 16.5 to 385 max. hp. You'll like the one common feature of all 24 engines: Fastest payback power for users. Just call or write International Harvester Co., Engine Sales Dept., Construction Equipment Division, Melrose Park, Illinois.

International® Construction Equipment

International Harvester Co., 180 N. Michigan Avenue, Chicago 1, Illinois

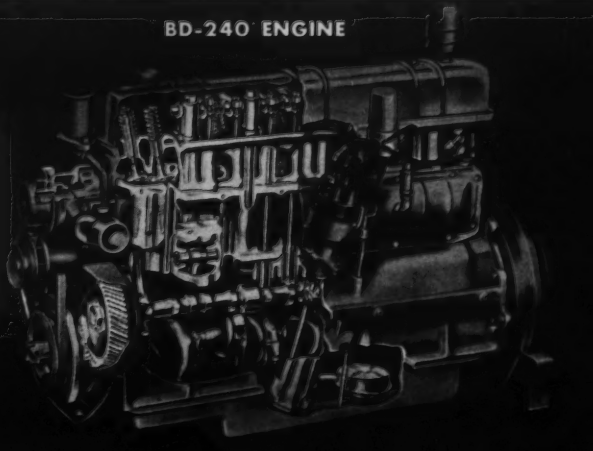
A COMPLETE POWER PACKAGE: Crawler and Wheel Tractors . . . Self-Propelled Scrapers and Bottom Dump Wagons . . . Crawler and Rubber-Tired Loaders . . . Off-Highway Haulers . . . Diesel and Carbureted Engines . . . Motor Trucks . . . Farm Tractors and Equipment.

Circle 459 on Page 19



Elgin White Wing, "America's foremost 3 cu yd motor pick-up sweeper," is driven by 6-cyl. BD-240 engine with 140.8 hp @ 3,800 rpm.

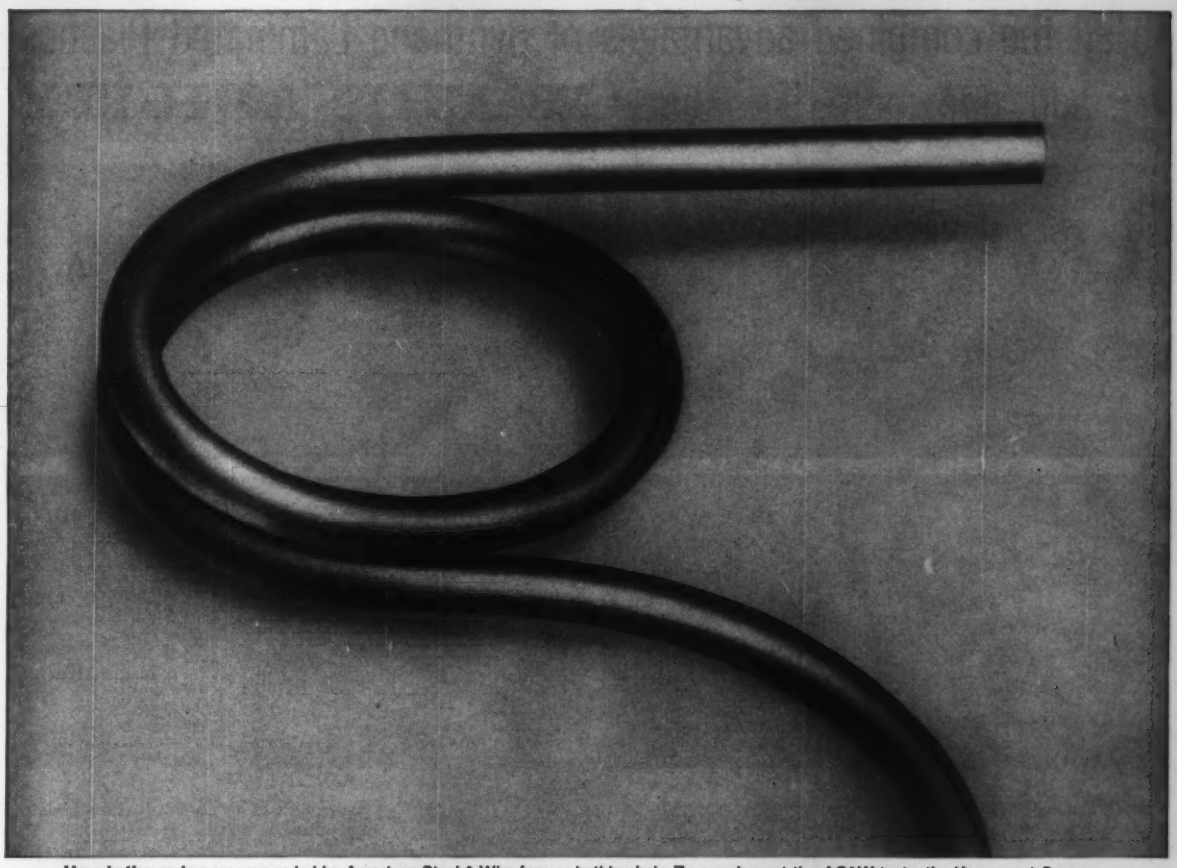
BD-240 ENGINE



20,000 chairs rock on USS American Springs without one failure

...thanks to AS&W

In the American Steel & Wire Spring Testing Laboratory, the springs recommended for the Homecrest Chair go through extensive tests. This Fatigue machine, by means of strain-gauge verification, simulates years of use in a relatively short testing time.



Here is the spring recommended by American Steel & Wire for use in this chair. To supplement the AS&W tests, the Homecrest Company subjected these springs to a simulated rocking test. Under a weight of 250 pounds, these springs were rocked 750,000 times, without failure.

Spring Engineering Research Service

The Homecrest Company, Wadena, Minnesota, wanted to add a swivel rocking chair to their line of modern, functional home furniture. However, they would produce this chair only if it could be a quality item that would give good, dependable service. While designing the chair, they checked with the American Steel & Wire Spring Engineering Consulting Service. The engineers studied the problem, ran extensive tests and finally recommended a pair of round wire helical single coil torsion springs. Using these springs, Homecrest designed, fabricated and marketed the chair. Today 20,000 of these chairs have been sold and not one failure of an AS&W Spring has been reported.

Mr. A. L. Englemann, a partner of Homecrest Company, says, "We have purchased from American Steel & Wire over 45,000 springs, and not one has been reported a failure. We couldn't be happier with American Steel & Wire as a supply source for our springs."

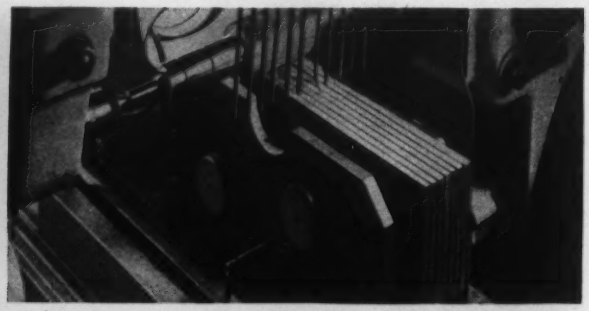
If you have a spring problem, or would like advice on the use of springs in your product, get in touch with any American Steel & Wire Sales Office. You can benefit from the knowledge of AS&W's Spring Engineering Research Service. The Service has been engaged in laboratory experiments of static and dynamic testing for 20 years and has accumulated invaluable data on stress and fatigue life of steel springs, while endeavoring to improve efficiency in the use of steels, from steel chemistry through product application, to more economically cope with today's rigorous demands. This accumulated knowledge of the AS&W Spring Engineering Research Service is at your disposal. *American Steel & Wire, 614 Superior Ave., N.W., Cleveland 13, Ohio.*

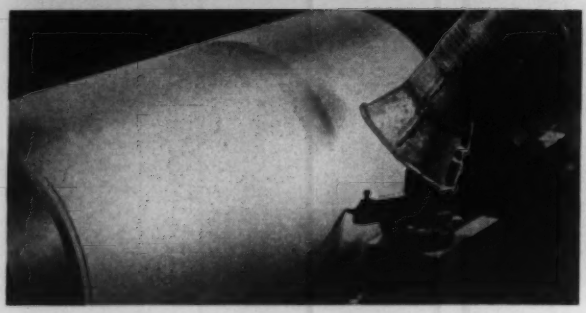
USS and American are registered trademarks

American Steel & Wire Division of USS **United States Steel**

Columbia-Geneva Steel Division, San Francisco, Pacific Coast Distributors • Tennessee Coal & Iron Division, Fairfield, Ala., Southern Distributors • United States Steel Export Company, Distributors Abroad

To all the combined advantages of Synthane Laminated Plastics . . . add one more big plus—**MACHINABILITY**





There are many reasons why plastic laminates such as Synthane are well regarded. They offer—in combination—resistance to heat, wear, chemicals, oil, water; light weight; excellent dielectric properties and mechanical strength; dimensional stability. On top of all these, however, is the one property that makes Synthane practical—Machinability.

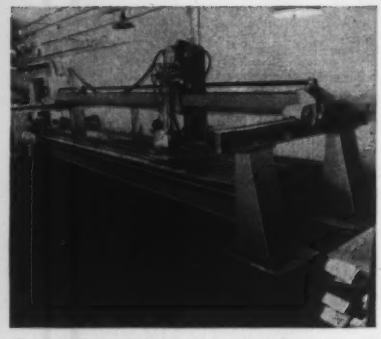
This means that whatever your application you may obtain parts of Synthane in the form desired and at a reasonable cost whether you require one or a million.

How Machinable Is Synthane?

Synthane laminates are easy to machine, using ordinary wood or metal working machinery with only a few modifications of method. As an example, here are some standard machining operations readily performed on Synthane:

Shearing	Screw Machine Operations
Band Sawing	Planing
Circular Sawing	Shaping
Drilling	Punching
Tapping	Broaching
Fly cutting	Shaving
Milling	Sanding
Gear cutting	Grinding
Turning	Boring
Turret Lathe Operations	Tumbling
	Buffing

Practically all of these operations can be handled on standard machines, many with standard cutters. But the nature of the material, being softer and more resilient than metal, and being laminated and a poor heat conductor, often makes the use of cutters with special rake and clearance, operating at special feeds and speeds, desirable.



Sawing long lengths. One of the numerous special tools whose advantages are available when Synthane fabricates the material.

The successful machining of Synthane laminates is aided by proper design of parts for ease of machining. A Synthane booklet: "Design Hints for Laminated Plastics*" adequately covers design recommendations.

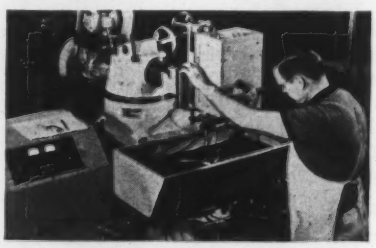
It pays to let Synthane machine laminated plastics for you

Although Synthane laminated plastics are easy to machine, it will usually pay you to have us handle the machining for you—for these reasons:

1. All of our equipment is especially designed or adapted for the fabrication of plastics.
2. We are constantly developing new, faster, and more economical methods of machining Synthane laminated.
3. We make all of our own tools, dies, fixtures and jigs, quickly and economically.
4. We relieve you of all production worries: machining errors, rejects, waste, mistakes in dimensions or tolerances, and delays in delivery.
5. Because we combine manufacturing and fabrication in one location, we can maintain high quality control while solving difficult machining problems. When necessary, we can even modify the properties of a given grade of material to meet special requirements.

For further information, write Synthane Corporation, 5 River Rd., Oaks, Penna.

**Booklet available upon request.*



Metal disintegration, a fast, economical way Synthane uses to produce or revise dies.

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Laminated Plastics for Industry

Sheets, Rods, Tubes, Fabricated Parts
Molded-laminated, Molded-macerated

Circle 461 on Page 19

Handle Any Adjustable-Speed Job with One of these Square D "packages"*

One of 13 CUSTOM DRIVES for an automotive plant for control of 6 miles of monorail conveyors

*a Square D "package" includes the power conversion unit, operator's station, and drive motor

ELECTRONIC DRIVES

employ advanced designs using more static elements and less tubes. Fail-safe circuits prevent motor runaways. Available in sizes from 1/20 H.P. through 40 H.P.

STATIC POWER MAGNETIC AMPLIFIER DRIVES

provide top reliability and simple maintenance. Save both floor space and weight as compared to conventional drives. Available in sizes through 400 H.P.

MOTOR-GENERATOR DRIVES

use static regulators and rectifiers for simplified maintenance. Rugged, heavy-duty components are provided in each drive. Available in sizes through 400 H.P.

CUSTOM DRIVES

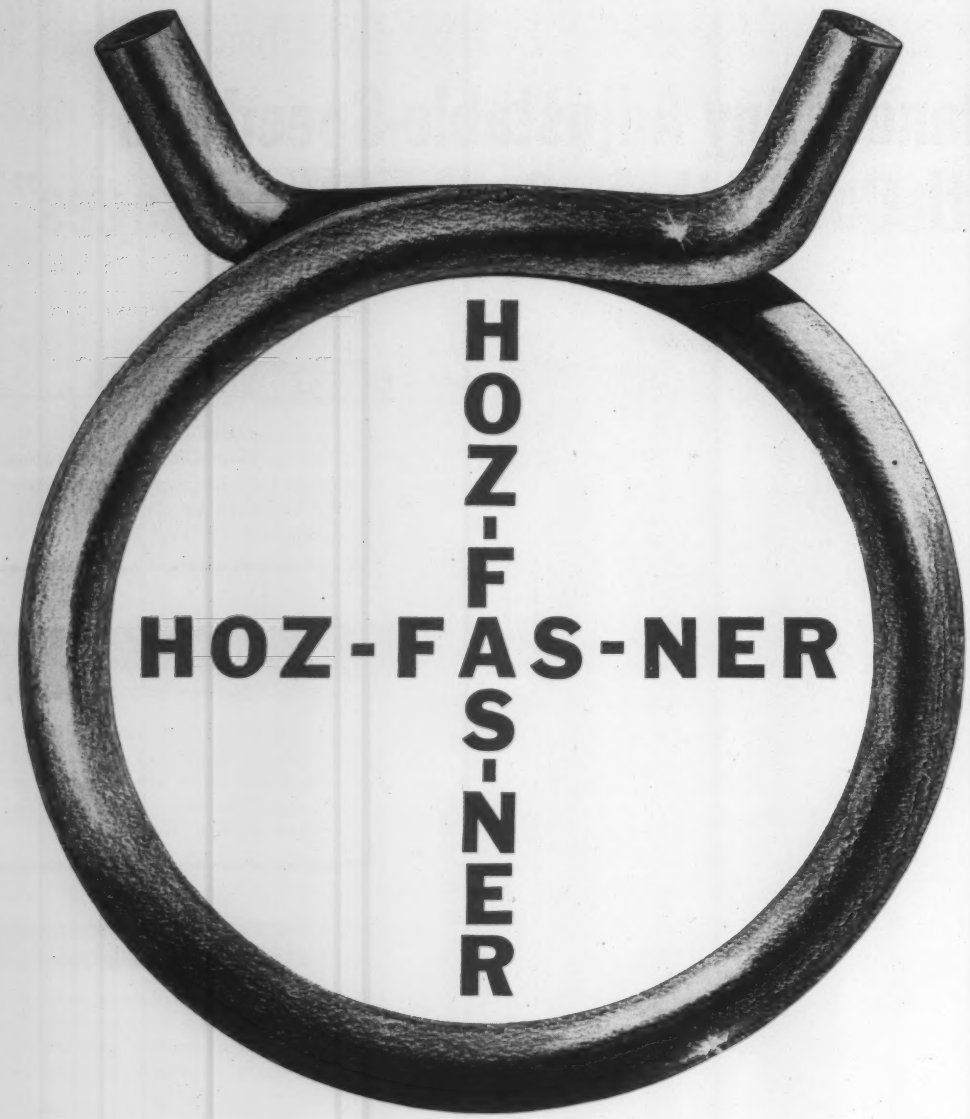
for every possible adjustable-speed requirement can be designed for you using combinations of the above units, plus special units, with accuracies to fractions of 1%. The answer to your adjustable speed problem is as near as your Square D field office.

No matter what adjustable-speed requirements you may have, you can select a Square D drive to meet them exactly. Moreover, every component—from control to drive motor—is subjected to a complete electrical test, and the entire drive is test-run at the factory to assure top performance on the job.

***Write** for complete details. Ask for Adjustable-Speed Bulletin. Square D Company, 4041 North Richards St., Milwaukee 12, Wis.*

EC&M HEAVY INDUSTRY ELECTRICAL EQUIPMENT...NOW A PART OF THE SQUARE D LINE

SQUARE D COMPANY



Nothing clamps a hose quicker, easier, or more economically than Eaton-Reliance Hoz-Fas-Ner®. This one-piece hose clamp goes on without fuss and bother — without time-consuming preassembly at the point of installation — and stays tight for the life of the hose. Never needs adjusting or tightening, and will not cut the hose. Hoz-Fas-Ners may be specified for both pressure and suction lines, since they exert continuous, uniform pressure at all points around the inner circumference. The simplicity of design of Hoz-Fas-Ners makes them economical in cost, yet this is not your only saving. Where installing hose clamps is a repetitive operation on assembly lines, Hos-Fas-Ners save substantially in high-priced labor. Because they are backed by the Eaton name, you can be sure of their high quality. Available in a full range of sizes. Write for specifications.

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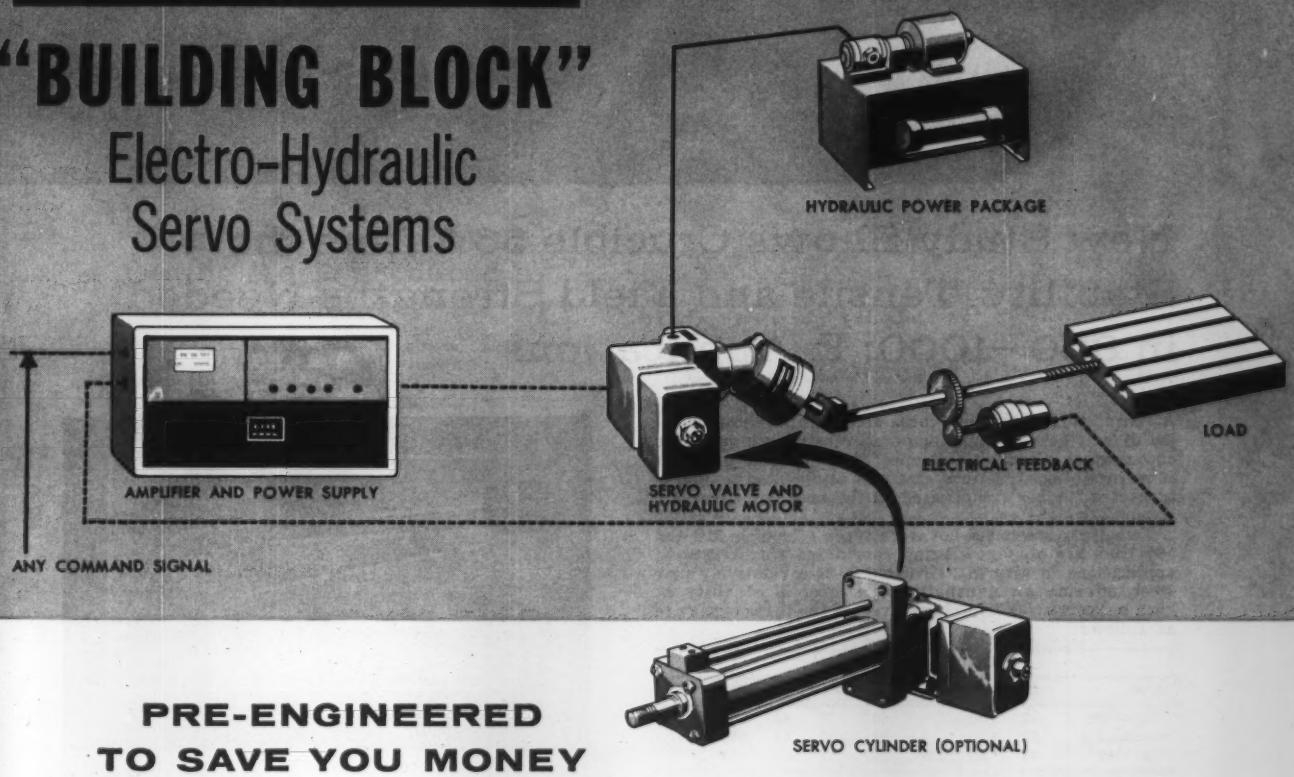
Circle 463 on Page 19

A NEW CONCEPT

"BUILDING BLOCK"
Electro-Hydraulic Servo Systems



PRE-ENGINEERED TO SAVE YOU MONEY

Standard hydraulic and electrical components are now pre-engineered into a series of complete and dependable Electro-Hydraulic Servo Systems. Vickers has the most extensive line of individual "building block" components available for such systems. Inherent "trim flexibility" makes possible systems which will satisfy a very wide range of application . . . at only a fraction of the cost usually incurred in specially engineered systems. A very substantial saving in lead time is now possible.

Vickers "Building Block" Closed Loop Servo Systems have proved their merit on machine tools, fabricating machines and processing equipment. The amplifier is precisely matched to the servo valve torque motor. The work load requirement is continuously monitored by electrical feedback devices to insure that directions (command signals) are accurately followed at all times.

Positional accuracy of better than .001 is obtainable with a hydraulic motor and lead screw. In many position applications, cylinders can be used with similar accuracies. Velocity can be maintained within one or two rpm. In addition to position and velocity controls now in service, constant horsepower and constant tension systems soon will be available. Any command signal may be used with these systems . . . from a simple potentiometer to complete numerical control. For further information, ask for Engneering Bulletin No. 59-75.

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ENGINEERS AND BUILDERS OF OIL HYDRAULIC EQUIPMENT SINCE 1921

Circle 464 on Page 19

Memo on Metals

New Study Shows Crucible 56 Offers the Stability, Tensile and Yield Strengths Needed in 800—1000° F. Applications

A recent study considers three steels which show promise of solving the high temperature strength problems encountered in today's high speed flight.† These problems of maintaining structural strength at elevated temperatures are further complicated by the need for favorable strength/weight ratios.

Two of the steels are hot work types (Crucible 218 and 56) that are only now being considered for structural applications in aircraft. Crucible 56 is a relatively new steel, offering an unusually high level of stability at high temperatures. The chemistries of the three steels are as follows:

CHEMICAL COMPOSITION

Grade	C	CR	NI	Mn	Mo	V	Si	Al
Crucible 56	.40	3.30		.60	2.75	.40	1.00	
Crucible 218	.38	5.20		.35	1.40	.50	1.10	
AISI 4340	.40	.80	1.80	.70	.25		.30	

Figs. A and B compare the tensile and yield strengths of the three steels at the exposure temperature. The curves show that both Crucible 56 and Crucible 218 proved superior in these tests. However, the hardness-tempering curve for Crucible 56 shows that it is more stable than the other analyses evaluated. Crucible 56 also offers higher hardness (and hence, strength) when tempered in the 1050-1100° F. range. As the comparisons indicate, it also has higher elevated temperature tensile and creep properties than Crucible 218, which is a conventional AISI type. In Fig. C, the isochronous (constant time) stress-strain curves illustrate the stability of Crucible 56 at the top of the service temperature range. With these curves it is possible to determine the stress at which creep becomes an important consideration.

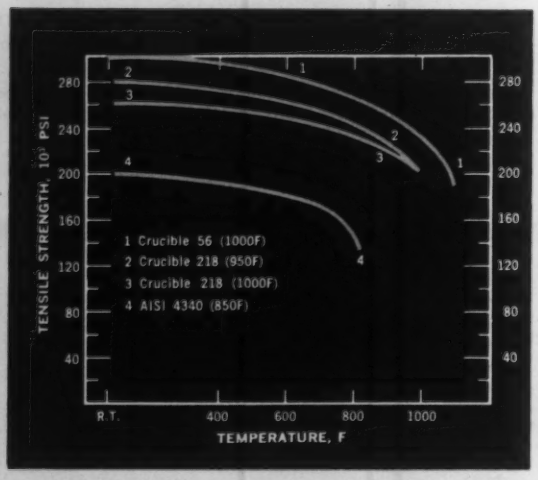


Fig. A. Tensile strength of various steels at exposure temperatures. Figures in parentheses are tempering temperatures.

†Although this study considers only aircraft applications, data given here may prove helpful in designing turbines, chemical processing and nuclear equipment, and other equipment where service temperatures ranging from 800-1000° F. are required.

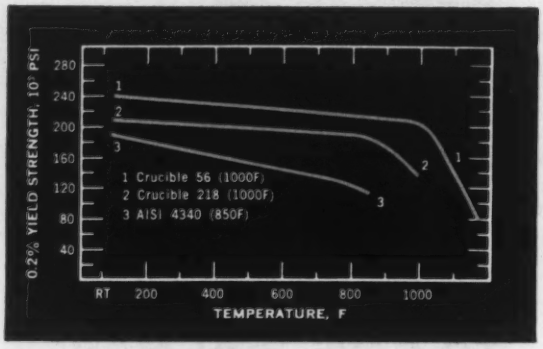


Fig. B. Yield strength (0.2% off-set) of various steels at exposure temperatures. Figures in parentheses are tempering temperatures.

For further details on Crucible 56 and other comparative data, send the coupon.

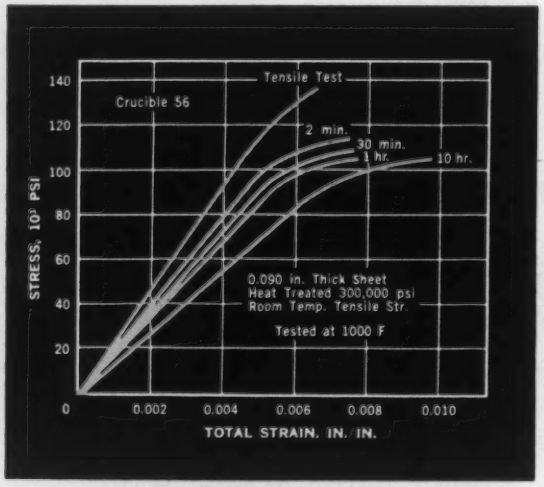


Fig. C. Isochronous stress-strain curves for Crucible 56 sheet show the outstanding creep properties of this steel which are higher than any other steel at 1000° F.

* high temperature strength
* vacuum melting
* cast properties of UHS-260

Compares properties of bearing steels produced by various melting techniques

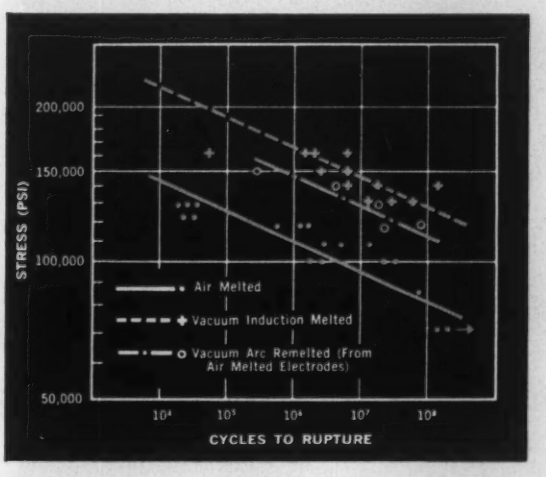
High vacuum technology has expanded considerably in recent years. The degree of improvement obtainable can be shown by comparing the properties of SAE 52100 produced by various melting techniques.

The following table gives gas content analyses of this chromium-carbon steel when produced by air melting (AM), air melting and vacuum arc remelting (AM+VAR), vacuum induction melting (VIM) and double melting (VIM+VAR):

Melting Technique	O(PPM)	N(PPM)	H(PPM)
AM	30	100	<1
AM+VAR	7	70	<1
VIM	5	3	<1
VIM+VAR	3	3	<1

Reduction in gas content is important, of course, because gases have varied detrimental effects on alloys. Oxygen increases transition temperature and forms various types of inclusions. Nitrogen effects aging, fatigue and stress rupture.

Similar improvement is obtained in cleanliness. (Inclusions strongly influence properties such as fatigue, impact and ductility.) Vacuum induction melted 52100 shows very small sulphide and oxide inclusions. Its background is extremely clean. Vacuum arc remelted 52100, made from air melted electrodes, also shows significant improvement over the air melted steel. Still further improvement is available with double melting.



Up to now, vacuum melted 52100 has been used mainly in bearings for jet engines, grinder spindles and instruments. It is credited with extending "B-10" life (the life at which 10% of the bearings fail) from 65 hours to 375 hours. Premature failures have been virtually eliminated. And the average number of production rejects of finished balls has dropped from 15% to 0.3%—savings that in some cases pay for the slightly higher cost of the vacuum melted alloy.

For more data on vacuum melted SAE 52100—or data on other vacuum melted ferrous and non-ferrous metals and alloys—send the coupon.

UHS-260 in cast form offers high strength with good ductility

New studies of the cast properties of UHS-260 should prove interesting to designers of structural parts for aircraft. In cast form at high temperatures, UHS-260 offers very high tensile strength with ductility equal to or better than transverse properties of the wrought form. Data from a preliminary report is given below. *For more complete information send the coupon.*

Grade UHS-260 Cast Properties —Preliminary Report

Nominal Composition

C	Si	Mn	Mo	Cu	Fe	Cr	Ni	V	Condition
0.35	1.50	1.35	0.30	—	Bal.	1.25	—	0.30	Hardened & Tempered

Mechanical Properties

	Test Temp °F.	Tensile Strength psi	Yield Strength psi	% Elong	% R.A.	Charpy Impact
Mean	−40°	265,000	218,000	6	10.5	7
High		268,000	226,000	6.5	15	8
Low		262,000	213,000	4	9	6
Mean	76°	260,000	217,000	4.5	12.5	7.7
High		265,000	241,000	6	16	8
Low		257,000	211,000	4	7	6
Mean	400°	266,000	191,000	5	7.3	11
High		269,000	205,000	6	10	13
Low		261,000	183,000	4	5	9
Mean	600°	237,000	162,000	9	18	11.3
High		240,000	172,000	10	23	12
Low		234,000	153,000	8	13	10
Mean	800°	200,000	147,000	9.6	29	12.3
High		232,000	179,000	13	42	13
Low		189,000	131,000	3	4	12

CRUCIBLE STEEL COMPANY OF AMERICA
Dept. EJ07, The Oliver Building
Mellon Square, Pittsburgh 22, Pa.

Gentlemen:

Please send me the following:

1. Crucible 56 Data Sheet_____ Comparative Data_____
2. Data sheet on vacuum induction melted SAE 52100_____
3. Data on other VIM metals_____
4. Further information on the cast properties of UHS-260_____

Name_____

Title_____

Company_____

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Circle 465 on Page 19

WHO SAYS

there's nothing new in Socket Set Screws!

The revolutionary P-K W-POINT Socket Set Screw is not only new—completely new—it is capable of delivering the highest degree of holding power ever attained...at no increase in price!

What's the difference between the new P-K W-Point and ordinary cup point set screws? It's the new pivot point that's built into the cup! This exclusive P-K feature reduces "wobble" caused by the required tolerance clearances between screw threads and the tapped hole . . . minimizes "tipping" motion imparted by key tightening . . . creates tracking which is uniformly even in depth and shape . . . results in frictional engagement of both cup edge flanks . . . provides:

30% more back-out torque

50% more resistance to vibration

50% more resistance to rotary slippage

Test this new socket set screw in your own plant. Ask your P-K Industrial Distributor for complete information and samples today, or write to P-K direct for technical bulletin No. 1106.

PARKER-KALON® W-POINT PATENT PENDING **Socket Set Screw**

PARKER-KALON, *a division of General American Transportation Corporation. Clifton, New Jersey. Offices and Warehouses in Chicago, Los Angeles.*

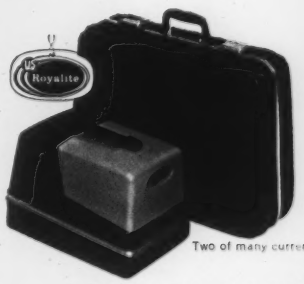
Circle 466 on Page 19

Circle 467 on Page 19→

Shape your product future with U.S. Royalite®

ABS THERMOPLASTIC SHEETS

Here is a versatile thermoplastic sheet material that forms to *any* shape in sharp detail—and still answers the basic design problems of toughness, beauty and economy. Used as a tool for advanced thinking, U.S. Royalite makes new, modern product designs practical. Check these advantages: (1) Royalite is extra tough to resist hard knocks and scrapes, is impervious to grease and oil, nonrusting and unaffected by most chemicals. (2) Royalite molds cleanly, without seams or sharp edges to snag or chip. (3) Royalite gives you new textured beauty in a wide range of colors built in to last. (4) Royalite is extra light, making portable products even more portable. (5) Royalite is economical to use. Advanced fabricating techniques permit its wide use on popular-priced items. Send for free, file-size specifications booklet.



Two of many current applications of U.S. Royalite

ROYALITE PLASTIC PRODUCTS

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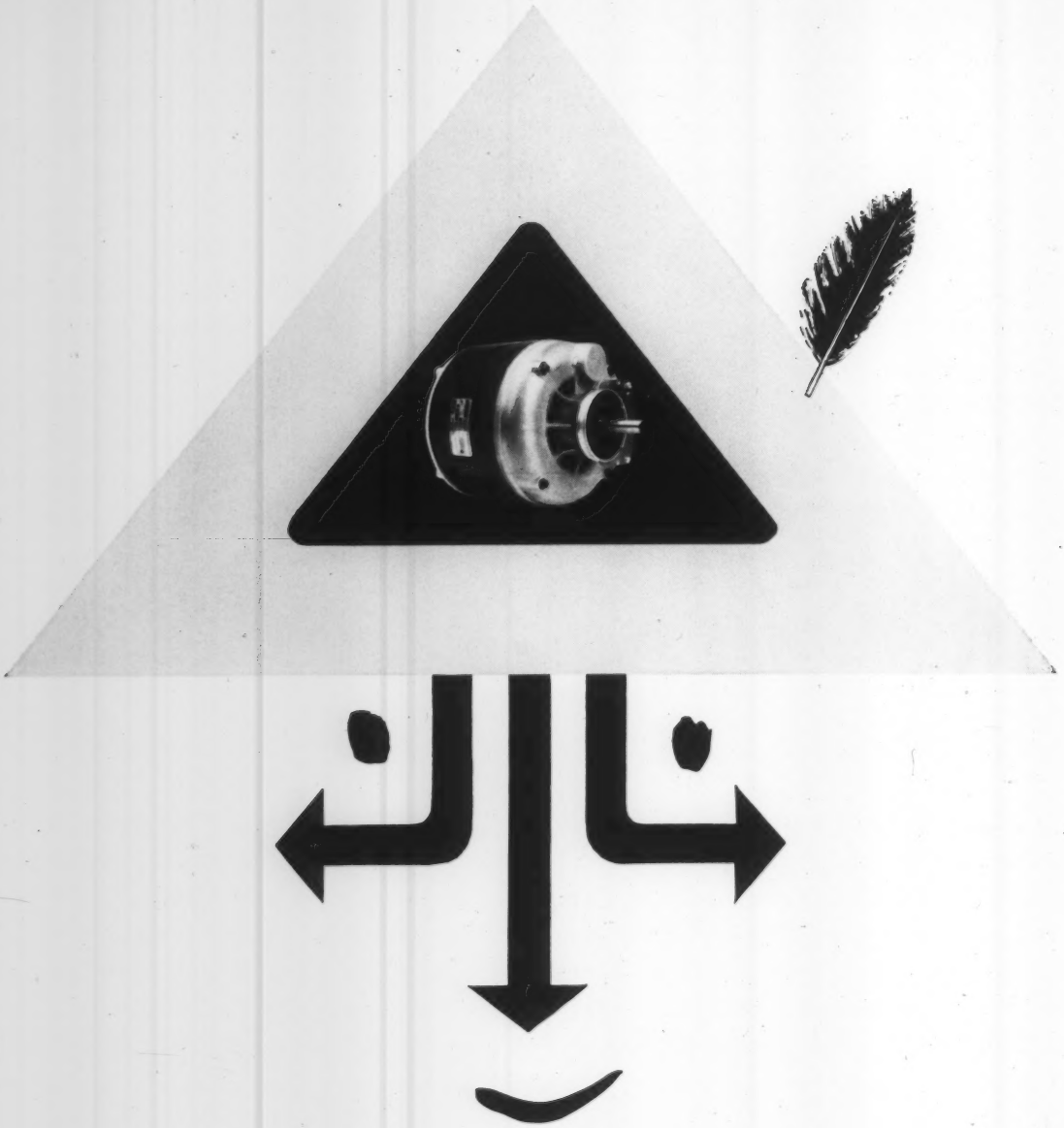

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Taking a new product idea from rough sketches on through to the finished product is a specialty at Packard Electric. Packard fractional horsepower motors are designed to fit the power needs of individual appliances. Our engineers will work with you right from the beginning to develop a complete motor with switches, power cord and mountings as required by your appliance. The outstanding success of Packard Electric in this highly specialized field is the result of 40 years' experience.

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GM GENERAL MOTORS

"Appliance Motor Specialists"

Circle 625 on Page 19

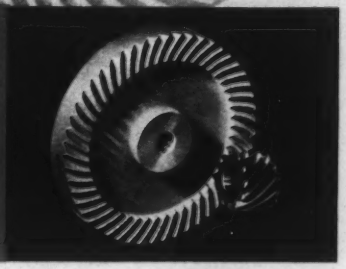
PLANOID® GEARS are low-ratio gears competitive with bevel and hypoid gears in efficiency and performance, but are manufactured at lower cost.

From Illinois Tool Works' unique family of gears . . .

SPIROID® GEARS

new gear economies with new gear efficiencies

HELICON® GEARS bring even greater production economy to high quantity applications than is possible with face, bevel or worm gears.



Shown here are typical examples of outstanding developments in right-angle gearing introduced by Illinois Tool Works. Pictured above is a Spiroid gear, the first major advancement in gearing in thirty years.

Spiroid® Gears do the same job as worm gears with this notable exception: they do it more economically and more efficiently in less space. They are recommended for application in the field of medium to high-ratio right-angle gearing. For maximum economy they may be sintered, molded or cast in metal or plastic; however, even hardened steel Spiroid gears for maximum power transmission are manufactured more cheaply than worm gears.

SEND TODAY FOR THESE NEW GEAR BOOKLETS Free booklets are available giving complete information on the design, manufacture, applications and advantages of each of these gears. Request your copies today.

Spiroid® gears

SPIROID DIVISION OF ILLINOIS TOOL WORKS

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Circle 626 on Page 19

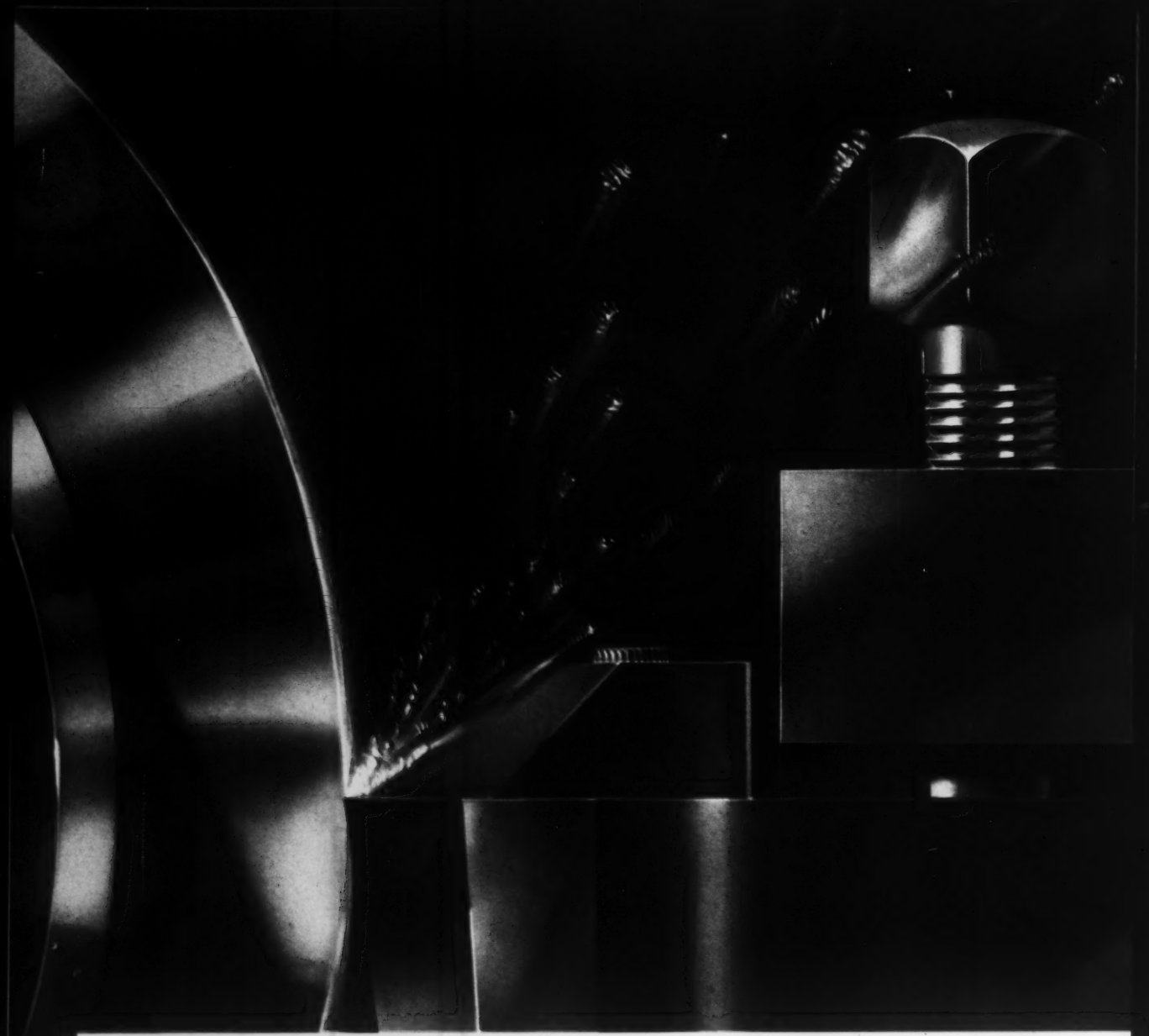


Illustration of Malleable casting being turned at 1,400 surface feet per minute with a 0.100" depth of cut using an oxide tool.

Machinability is Malleable

It's the finished cost of machined components that's important to you. Remember then . . . Malleable iron is more machinable than any other ferrous metal of similar properties. With Malleable castings you'll reduce machining time as much as 50% . . . increase tool life up to 250% . . . get unexcelled surface finishes . . . and end your reject problems.

To find out how much you can cut your costs and improve your profits, contact one of the progressive firms that displays this symbol—

MEMBER
MALLEABLE
CASTINGS COUNCIL

If you wish, you may inquire direct to the Malleable Castings Council, Union Commerce Building, Cleveland 14, Ohio, for information.

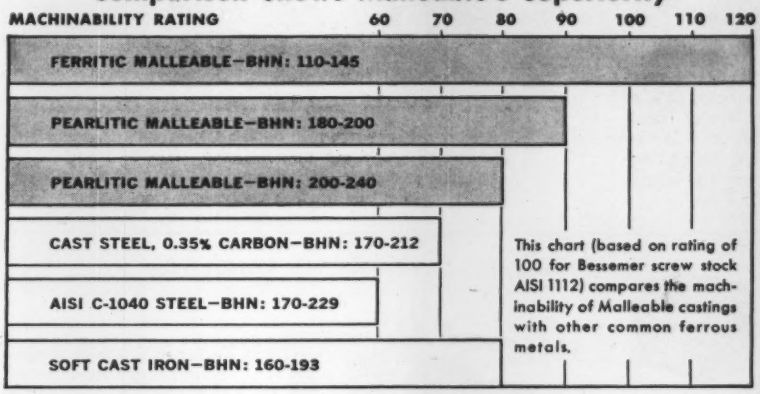
Machining Malleable Castings—Important Key to Cost Reduction

Malleable castings—the most machinable of all ferrous metals—cut quality components costs

Production men know that machining time, power consumption and rejects drop with the use of Malleable iron castings, while tool life and profits shoot up. The reason is simple: Malleable iron is the most machinable of all ferrous metals of similar properties.

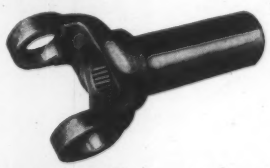
The following important factors work together to give Malleable such machining superiority: Malleable's microstructure contains tiny, evenly distributed nodules of carbon that help cutting tools quickly break the removed metal into small (Class A) chips; the carbon also acts as a lubricant, prolonging tool life; uniformity of properties throughout every casting permits running at optimum machining conditions.

Comparison Shows Malleable's Superiority



Typical Example Shows Savings of 70% to 250%

The conversion of automotive universal joint yokes from steel forgings to pearlitic Malleable castings typifies the savings provided by Malleable castings. Costs for the rough pieces and performance characteristics of the two materials are comparable. However, the castings are much more economical to machine. Considering that machining often costs two to four times as much as the rough parts, the economy resulting from using Malleable castings is substantial.



Conversion of this universal joint yoke to a Malleable casting increased production, lowered direct and tool room labor, and cut tool replacement.

One volume user of Malleable joint yokes reports the following savings after changing from steel to Malleable castings: 70% longer tool life in broaching the splines; 250% more pieces cut by the nut seat cutters; 149% more pieces in turning and facing the hub; an increase of 100% in production between wheel dressings in grinding the hub; 246% greater production in drilling the cross holes.

In each of these operations, the change to Malleable castings cuts direct production time by reducing the frequency of tool changes. Tool room labor and tool replacement are both reduced to fractions of their previous costs.

Throughout the metalworking industry, part after part is now being initially designed of Malleable or converted from other materials to take advantage of Malleable's unrivalled machinability . . . to produce better parts at lower costs.

New Information Now Available on Machining Malleable

Data Unit 106—Machinability of Malleable Castings—can be obtained from any member of the Malleable Castings Council, or from the Malleable Castings Council, Union Commerce Building, Cleveland 14, Ohio.

These companies are members of the

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New Haven Malleable Iron Co., New Haven 4

DELAWARE
Eastern Malleable Iron Co., Wilmington 99

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Wagner Castings Company, Decatur

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MICHIGAN
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Circle 468 on Page 19

6 SIX WAYS TO DESIGN FOR operator comfort

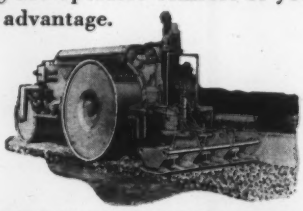
Protecting the operator from the discomfort and fatigue of vibration/shock/noise has become a vital consideration in modern equipment design.

Exposure to the subtle effects of vibratory disturbances can affect operator equilibrium, cause motion sickness or impair efficiency, morale and mental attitude. These in turn can lead to lower output, complaints, equipment misuse and accidents.

Check the ideas presented here for ways of upgrading the operator comfort of your product. The result could be an important competitive advantage.

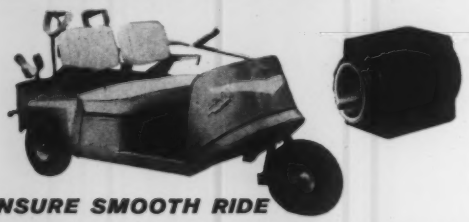
1 REDUCE SHOCK AT HANDLE

Shock absorbing handle on pneumatic rock drill eliminates 55% of tool shock without loss of impact at bit. Lord Dynaflex Joint in handle linkage is flexible torsion member which reduces operator fatigue. Result: higher daily output.



2 PROTECT FROM VIBRATORY DISTURBANCES

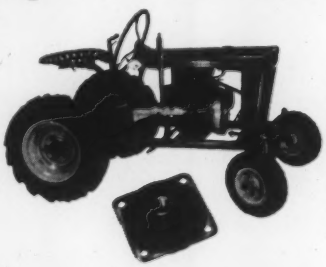
Vibratory compactor on road roller produces 4200 three-ton jolts per minute which can turn operators' legs to "jelly". Lord mountings applied at vibrator shoes isolate 98% of vibration, protect operator and machine components from fatigue.



3 INSURE SMOOTH RIDE

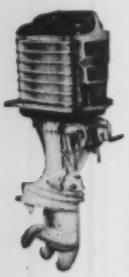
Lord Dynaflex Joints, incorporated in front wheel fork, eliminate "bounce" and provide excellent riding and steering characteristics. Golf car manufacturer reports that elastomeric spring is "most durable shock absorbent unit available."

4 ISOLATE ENGINE VIBRATION



Garden tractor with single-cylinder engine base-mounted on flexible suspension enjoys competitive advantage of relaxed, vibrationless ride. Lord Plate Form Mountings isolate firing and torque disturbances, provide stability against drive belt pull.

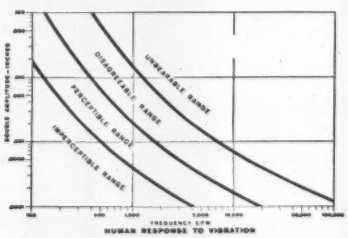
5 ASSURE QUIET OPERATION



Lord Dynaflex Mountings on outboard engines reduce structure-borne noise, isolate engine and propeller vibrations, absorb power impulses and inertia forces. Elastomeric units contribute to "soft sound" and greater passenger comfort.

6 USE THIS HELPFUL DATA

This Human Response to Vibration Curve will guide you in designing your equipment for greater operator comfort. And for authoritative assistance in vibration/shock/noise control, rely on the unmatched experience of Lord engineers.



Contact the nearest Lord Field Engineering Office or the Home Office, Erie, Pa.

FIELD ENGINEERING OFFICES

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BOSTON, MASS. · HAncock 6-9135
CHICAGO, ILL. · Michigan 2-6010
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"In Canada—Railway & Power Engineering Corporation Limited"

LORD MANUFACTURING COMPANY • ERIE, PA.

LORD® BONDED RUBBER

Save 27% or more in cost...

NEW

Miller

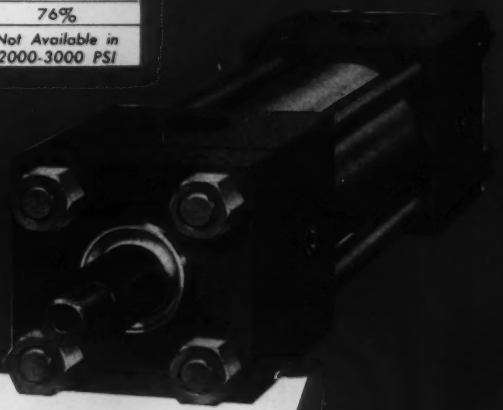
"JOB RATED"

HYDRAULIC CYLINDER LINE

JOB RATED, MODEL " J "

BORE	SEVERE OPERATING CONDITIONS	MODERATE OPERATING CONDITIONS	YOU SAVE THIS % IN PRICE OVER STANDARD 2000-3000 PSI CYLINDERS
1½"	1500 PSI	2500 PSI	27%
2	1500	2500	27%
2½	1000	1500	28%
3¼	1500	2500	32%
4	1000	1500	35%
5	800	1200	37%
6	800	1200	43%
8	500	800	50%
10	500	800	71%
12	500	800	76%
14	500	800	*Not Available in 2000-3000 PSI*

with IDENTICAL seals, design, and safety factors as the famous Miller "Power-Packed" Model "H" Line for 3000-5000 psi service.



SEAL FAILURE MEANS CYLINDER FAILURE!

1. *No seal made of synthetic rubber is compatible with even 50% of available, commercial, petroleum base hydraulic fluids.*

MILLER Uses All Teflon* Seals to Eliminate External Oil Leakage because Teflon is impervious to all known hydraulic fluids, even fire-resistant types.

TEFLON SHEF SEAL At Tubing Ends

No blind assembly. Is
Shear-proof
Heat-proof
Extrusion-proof
Fluid-proof

TEFLON Seals On Piston Rod And Bushing

Teflon rod flange seal requires no adjustment. Teflon bushing seal is shearproof. Teflon wiper keeps dirt out.

TEFLON Seals On Ball Check And Adjusting Screw

Non-protruding, self-locking, cushion adjusting screw interchangeable with ball check for easy access.

MILLER Uses Resin-Impregnated Leather Piston Cup Seals because they are compatible with petroleum base fluids and some fire-resistant types. Teflon cups available at small extra cost.

2. *Nicked or scored piston rods cause seal failure*

MILLER Uses Case-Hardened Chrome-Plated Piston Rods because they prevent nicks, scoring and rust.

S SHEAR PROOF
H HEAT PROOF
E EXTRUSION PROOF
F FLUID PROOF
SEAL
Teflon Pressure Energized
Hydraulic Cylinder Tubing End Seal
PAT. APPLIED FOR

OTHER MILLER QUALITY FEATURES
- Rust-Resistant Surfaces
- Interchangeable, Space-Saving Square, 4-Tie-Rod Design
- Precision Honed Barrels

Circle 470 on Page 19

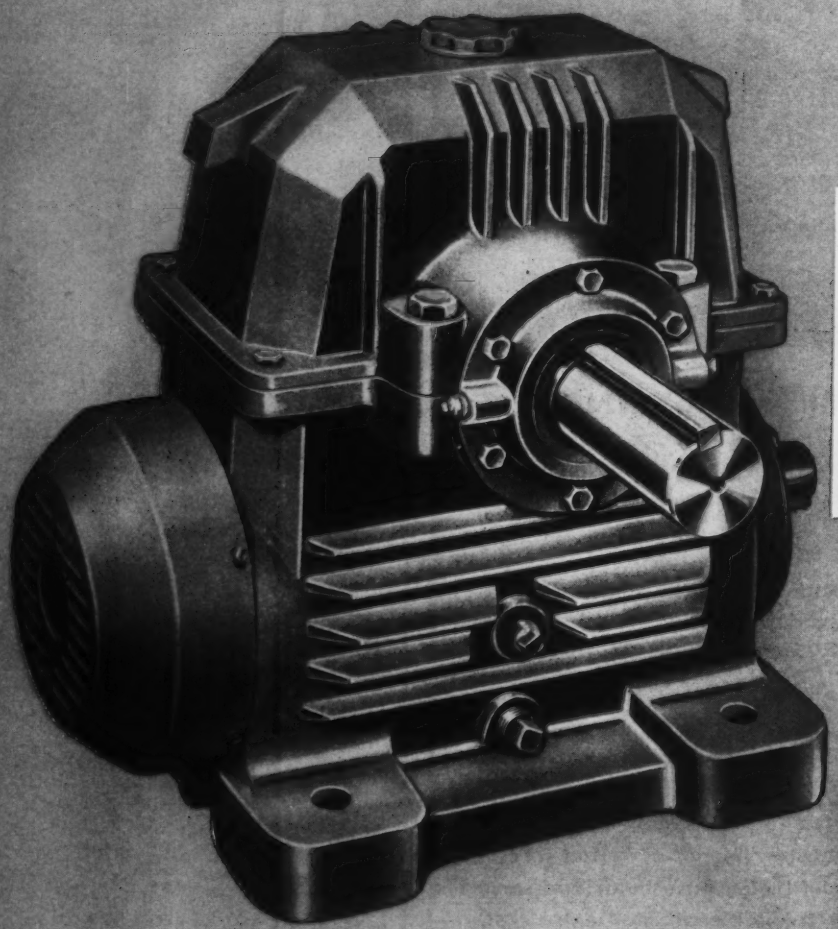
MILLER FLUID POWER

7N016 YORK ROAD, BENSENVILLE, ILL.

AIR AND HYDRAULIC CYLINDERS • ACCUMULATORS
COUNTERBALANCE CYLINDERS • BOOSTERS

DELROYD
SPEED REDUCERS

De Laval Announces All New Line of Single Reduction Speed Reducers



DELROYD
TYPE B
fan cooled 5" through 12" center distance
★

Send for this new 32-page Bulletin 3805 today.

New Delroyd single reduction speed reducers are available in a wide range of sizes and horsepower ratings. These worm gear units include centrifugally cast gears and fan cooling, and carry *the new AGMA ratings.*

DE LAVAL *Steam Turbine Company*
858 NOTTINGHAM WAY, TRENTON 2, N. J.

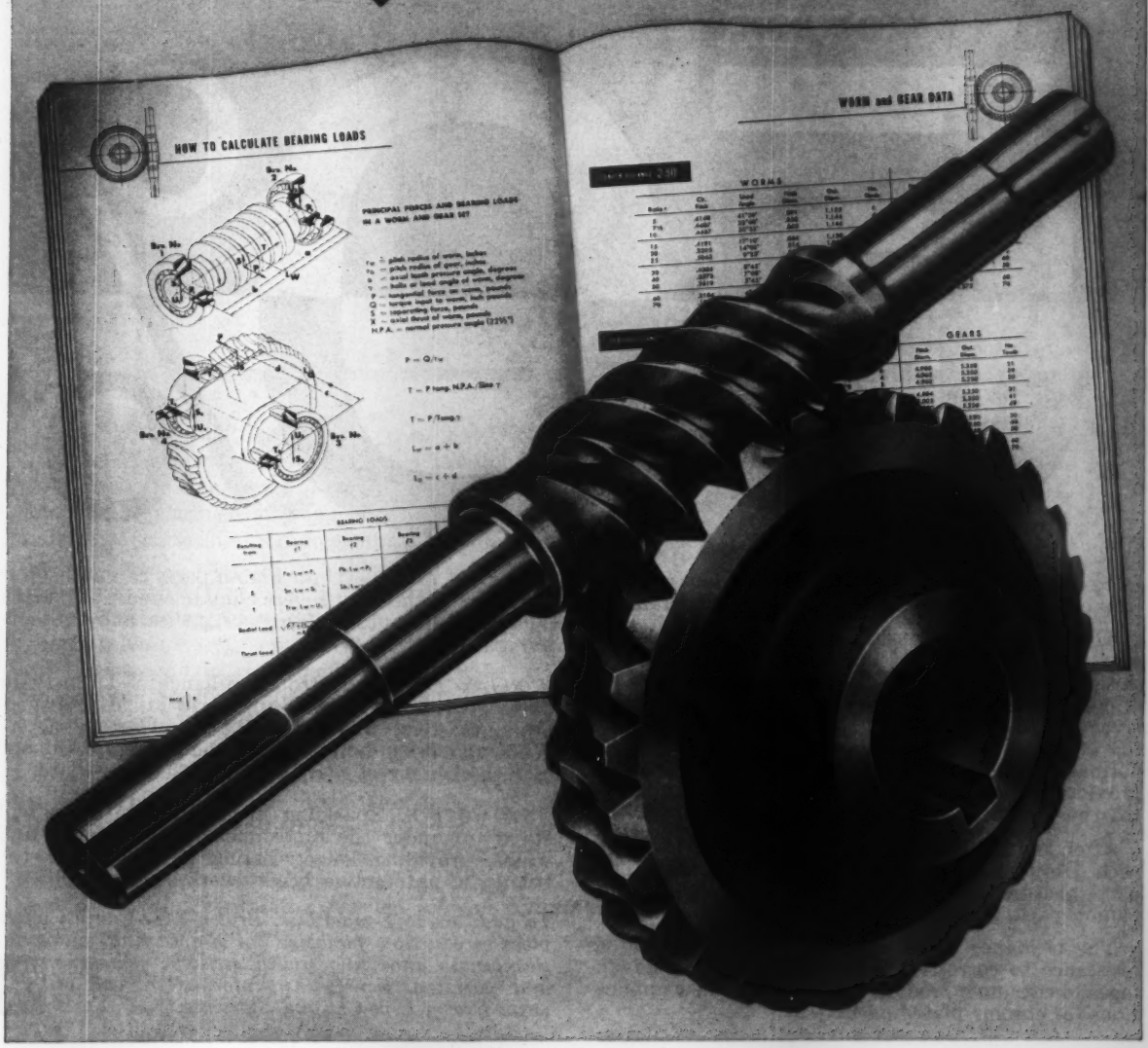
DL 479

DELROYD
WORM GEAR SETS

New high efficiency... higher horsepower ratings

JUST OUT

Send for this new Delroyd Worm Gear Sets Catalog #3800. It contains comprehensive information on selection of worm gears, calculation of bearing loads, and other data, much of which has never been published before.



DE LAVAL *Steam Turbine Company*

858 Nottingham Way, Trenton 2, New Jersey

DURA-PLATE INCREASES DURABILITY OF CHROME-PLATED PARTS BY OVER 50%

Dura-Plate, the new Brown-Lipe-Chapin process, gives chrome-plated parts a new dimension in durability.

New Dura-Plate consists of a duplex nickel base *plus* a thicker layer of crack-free chromium. Two-thirds of the initial layer is semi-bright nickel which is columnar in structure. The remaining one-third layer is bright nickel with a laminar structure. On top of this is a layer of chromium up to five times normal thicknesses. Together these three elements provide a higher degree of resistance to corrosion than has ever been achieved by conventional processes.

After 18-hour CASS Tests and actual field surveys with Dura-Plated parts, results showed that these parts resisted corrosion up to 50% more than companion parts plated by conventional methods.

The brilliance of Dura-Plate plus its outstanding resistance to corrosion adds important sales advantages to consumer products and opens up new applications for chrome-plated parts.

OUTDOOR LIVING: Dura-Plated parts can withstand the rigors of the most severe climate conditions, making it ideal for outdoor furniture, grilles, and outdoor-living accessories.

APPLIANCES: The lustrous brilliance of Dura-Plate parts provide extra sales appeal to ranges, refrigerators, toasters, washers and dryers. Grease detergents and other household cleaning agents will not mar the beauty of parts plated with Dura-Plate.

AUTOMOTIVE: Sparkling trim of Dura-Plate will stand up under the punishment of salt, snow and water, providing longer lasting protection for the beauty of automotive bright work.

In addition to Dura-Plate, Brown-Lipe-Chapin offers mass production facilities for die casting, all metal stampings, anodizing, rolled sections, polishing and painting. For further information, call or write Brown-Lipe-Chapin, Syracuse, New York.

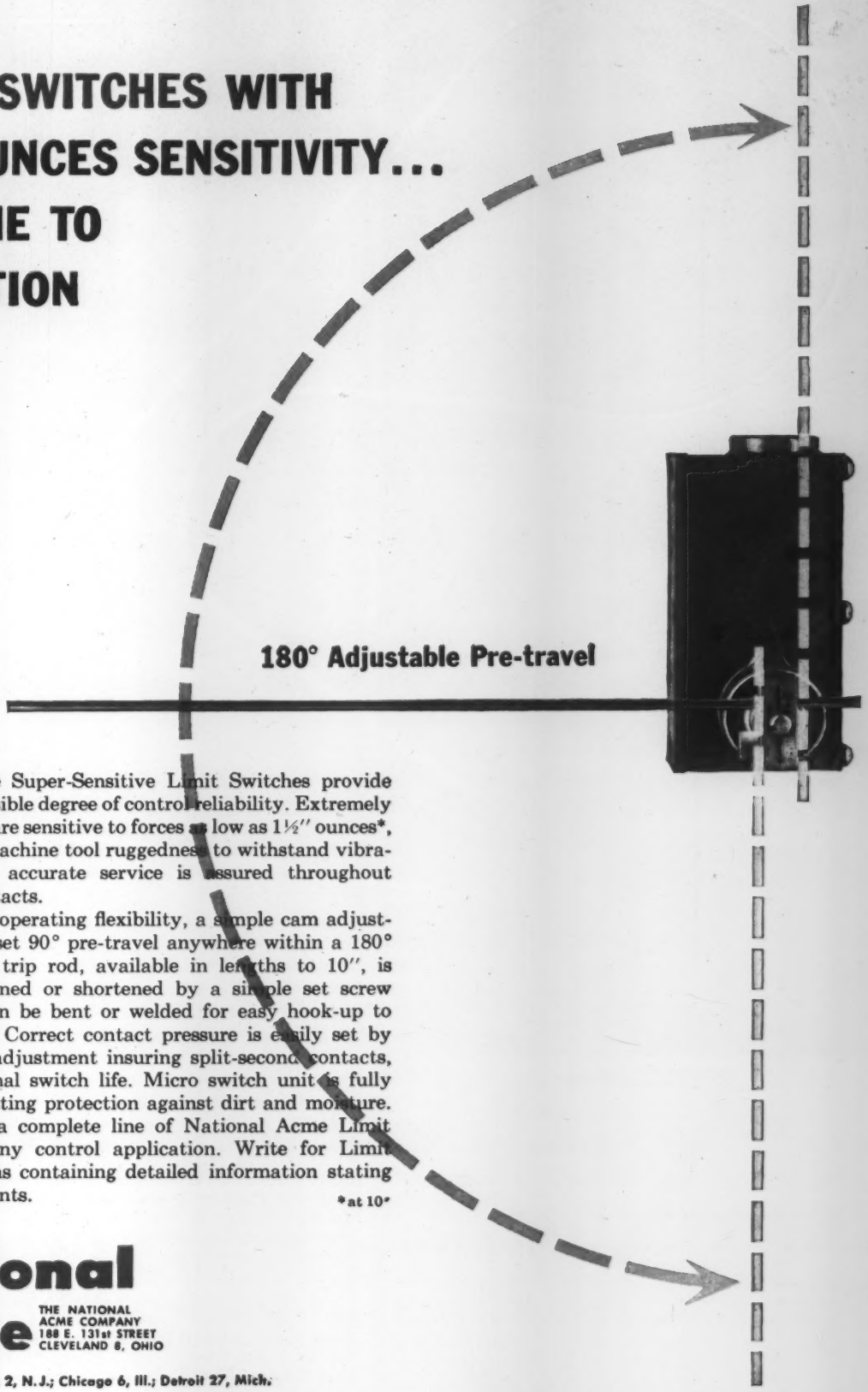
GM GENERAL MOTORS

RELIABILITY by BROWN · LIPE · CHAPIN

DIVISION OF GENERAL MOTORS CORPORATION

Circle 471 on Page 19

LIMIT SWITCHES WITH 1½" OUNCES SENSITIVITY... IMMUNE TO VIBRATION



National Acme Super-Sensitive Limit Switches provide the highest possible degree of control reliability. Extremely compact, they are sensitive to forces as low as 1½" ounces*, and yet have machine tool ruggedness to withstand vibration. Reliable, accurate service is assured throughout millions of contacts.

For extreme operating flexibility, a simple cam adjustment lets you set 90° pre-travel anywhere within a 180° arc. The steel trip rod, available in lengths to 10", is readily lengthened or shortened by a simple set screw adjustment; can be bent or welded for easy hook-up to other linkages. Correct contact pressure is easily set by a steel spring adjustment insuring split-second contacts, ten times normal switch life. Micro switch unit is fully enclosed for lasting protection against dirt and moisture.

Select from a complete line of National Acme Limit Switches for any control application. Write for Limit Switch Bulletins containing detailed information stating your requirements.

*at 10°

National Acme

THE NATIONAL ACME COMPANY
188 E. 131st STREET
CLEVELAND 8, OHIO

Sales Offices: Newark 2, N.J.; Chicago 6, Ill.; Detroit 27, Mich.

FLAT BELT REQUIRED

POLY-V ACTUAL SIZE

COMPACT, MODERN AUTOMATIC WASHER

Here's a typical example of efficient, compact, modern design—an automatic washer with a Dayton Poly-V Drive. Note that it imposes three design requirements, (1) a torturous back bend (2) sub-diameter pulleys (3) a limited tension take up area. Yet the design is efficient because Dayton V-belt engineers applied Poly-V to overcome these three punishing conditions.

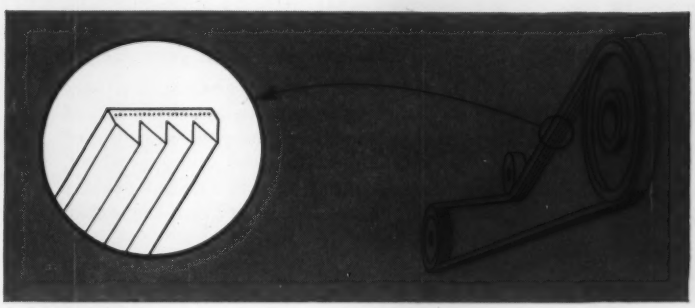
As you can see, use of Dayton Poly-V results in important savings in space, weight and costs . . . a more compact and lighter drive because of greater flexibility and load carrying capacity. You'll also find that Dayton Poly-V drives protect you against expensive "warranty" service calls.

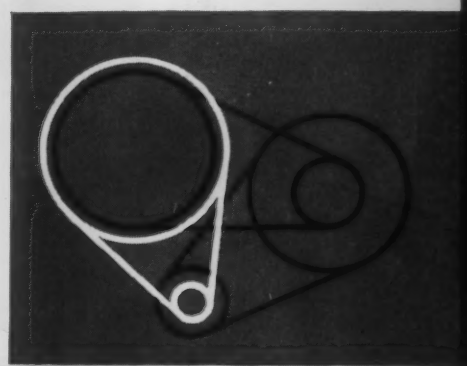
Announcing a new Drive Engineering Service

New DAYTON POLY-V® Drives provide unique answer to problems of space-saving modern design...

Delivers up to 50% more power in ⅔ the space. Never before has one product answered so many basic design problems . . . necessary to the rendering of tomorrow's more compact and functional appliances. Wherever greater power delivery is required within critical space limitations, Dayton Poly-V provides the answer with narrower sheaves, shorter centers, more speed ratios . . . *greater power delivery in less drive space.*

New Dayton Poly-V employs a single, endless parallel V-ribbed belt running in sheaves designed to mate precisely with the belt ribs. Single unit design provides twice the tractive surface per inch of sheave width . . . delivers up to 50% more power in as little as ⅔ the space where these requirements are indicated. This means *less* shaft overhang, less bearing load . . . a more compact and lighter drive. Single unit design completely eliminates need for matching belts, helps maintain constant pitch diameter and speed ratios from *no* load to *full* load. You get longer drive life . . . smooth vibration-free performance . . . greater dependability.





FULL POWER WITH SINGLE REDUCTION

Dayton Poly-V makes it possible to eliminate one stage of a double reduction drive. Its complete flexibility and high strength design takes high speeds (to 10,000 FPM) without snapping. Means it will deliver equal power in as little as ⅓ the space.

Back-side idler drives are no problem for the Poly-V longitudinal ribbed, highly flexible construction. Other belt drives crack from the force of flexing in a direction contrary to their normal construction. Dayton Poly-V offers long life, superior performance where others fail because of its uninterrupted synthetic cord construction running the entire width of the belt . . . providing amazing resistance to this gruelling drive condition.

® Registered trademark of R/M Inc. Manufactured by Dayton Rubber under exclusive license of Raybestos-Manhattan, Inc.

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Dayton Industrial Products Co.

Melrose Park, Ill.

A Division of The Dayton Rubber Co.

Circle 473 on Page 19

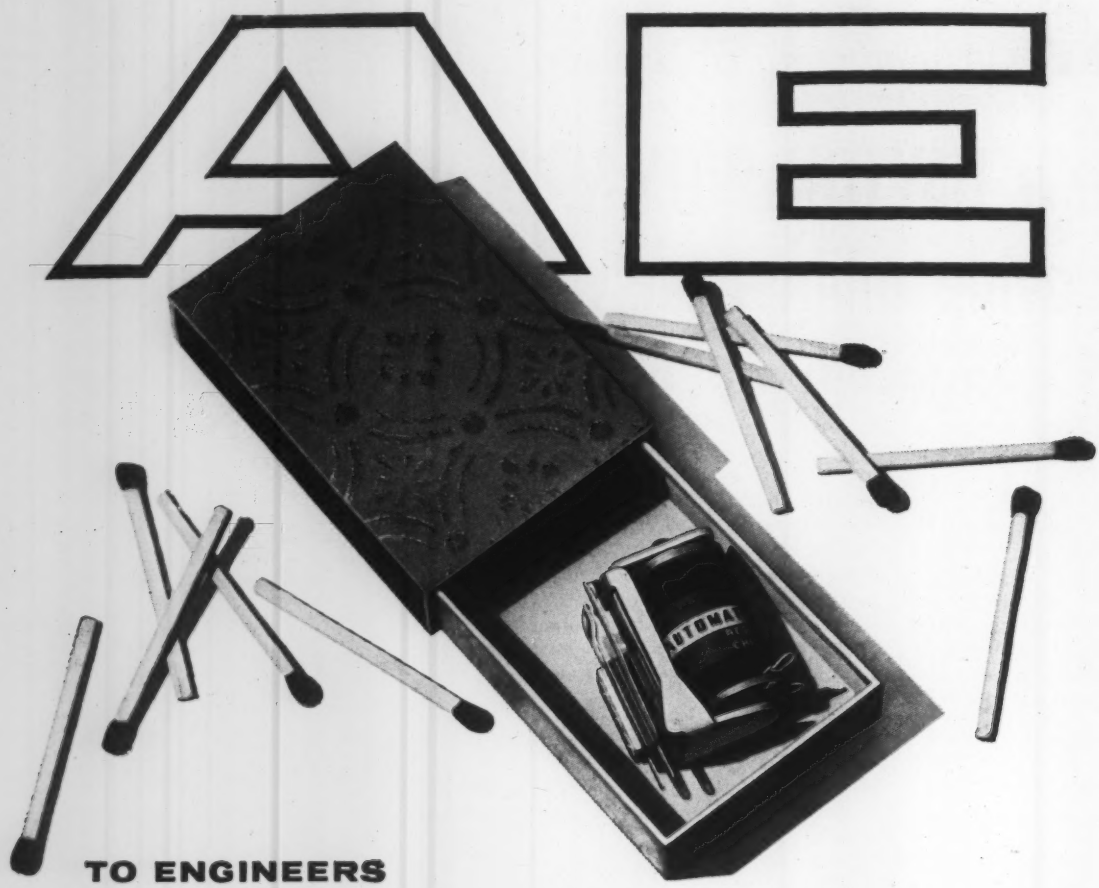
Make use of Dayton's special Drive Engineering Service when you think of power transmission . . . when your design is still on the drawing board. Attach this coupon to your Company letterhead, fill in as indicated.

Name_____

Company_____

Address_____

City_____ Zone_____ State_____



TO ENGINEERS

concerned with inner space

When there's no space to spare in your design, consider AE Class S relays. A basic Class S measures only 1 7/16" x 1 3/8" x 11/16" and weighs only 2 ounces.

Or, if you need a stepping switch, we have one no larger than a pack of king-size cigarettes.

Relay or switch, they're as uncompromising in quality *and* ability as their larger brothers.

As an example: the Class S miniature has many of the features of the premium-quality Class B—including sure-footed independent twin contacts.

There's another way we can help on the space problem. AE engineers have had years of experience in devising simplified circuits with complex capabilities for automatic telephone exchanges. Could be we could show you how to save a relay or two in your design. No harm in asking.

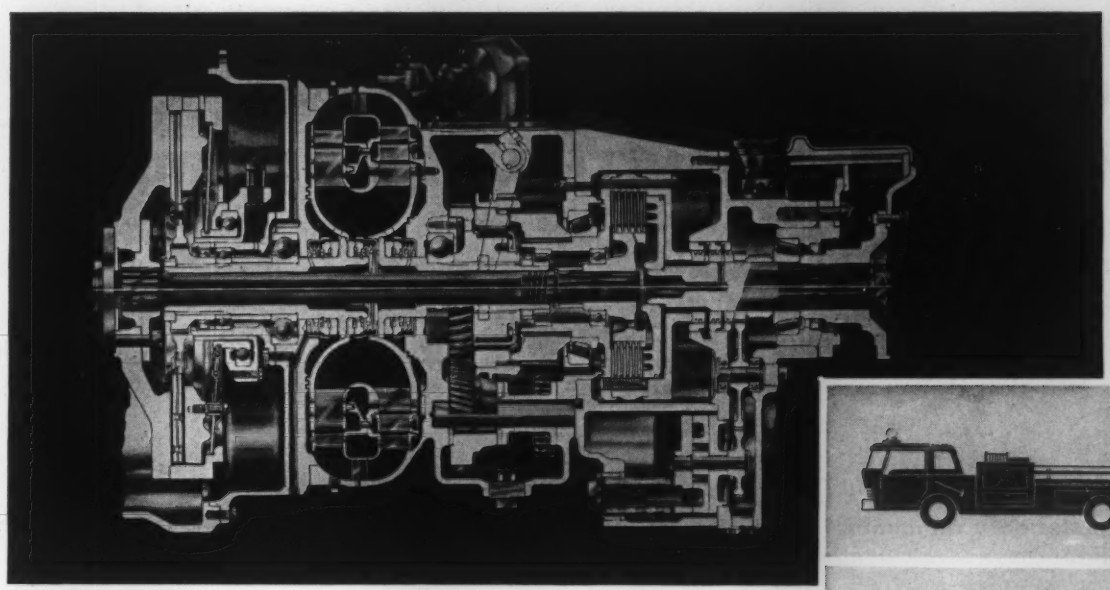
Or, if you'd like to put the switching end of the operation in our hands, we're equipped to supply completely wired and assembled, custom-built control units *or help you develop systems* to handle anything from sequential programming to . . . you name it.

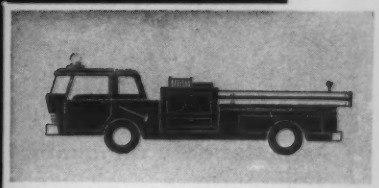
Want to get together? Just write the Director, Control Equipment Sales, Automatic Electric, Northlake, Illinois. If you'd like literature ask for our Circular 1702-E: *Relays for Industry*, and the new 32-page booklet on *Basic Circuits*.

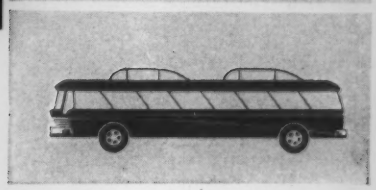
AUTOMATIC ELECTRIC

Subsidiary of
GENERAL TELEPHONE & ELECTRONICS

Circle 474 on Page 19







Spicer 183 Turbo-Matic...

The Transmission That Thinks for Itself!

Just turn the ignition key and accelerate . . . the 183 Turbo-Matic does the rest. Acceleration is smooth and rapid from standstill to direct drive, regardless of load condition or driver skill. The mental and physical fatigue of professional driving is materially reduced. Drivers are fresher, more alert, all day.

In buses and emergency vehicles Turbo-Matic multiplies available engine torque by as much as 5.6 times to provide unexcelled power utilization for improved operating efficiency and minimum maintenance downtime.

Many American cities have discovered the operational advantages of the heavy-duty Spicer 183 Turbo-Matic transmission. Ask the Dana engineers to help you adapt it to your vehicles.

. . .

Write for your free copy of booklet No. 806, which describes the outstanding features of the Turbo-Matic transmission.

DANA Spicer

DANA CORPORATION

Toledo 1, Ohio

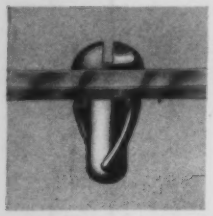
Serving Transportation—Transmissions • Auxiliaries • Universal Joints • Clutches • Propeller Shafts • Power Take-Offs • Torque Converters • Axles • Powr-Lok Differentials • Gear Boxes • Forgings • Stampings • Frames • Railway Drives

Many of these products are manufactured in Canada by Hayes Steel Products Limited, Merritton, Ontario

Circle 475 on Page 19

How can you use SPRING-LOCK?

THE FASTENER WITH USES UNLIMITED

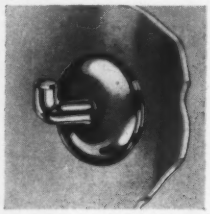


As a standard removable fastener or a blind rivet

A quarter-turn locks, unlocks. Load-carrying steel arms lock securely, don't loosen under vibration. One-piece (no receptacle) simplifies blind fastening.

As a roller axle

Now used on range drawers, kitchen cabinets, file cabinets, desks. Cuts installation costs, saves time. Designed to suit. Available with or without roller.

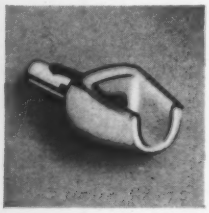


As cup hooks

High-strength polystyrene or chrome-plated die cast zinc. Inexpensive, sturdy and good-looking. Simply and quickly installed with a twist of the wrist.

As a cabinet door strike

Millions in use on kitchen cabinets, automatic dishwashers, etc. Standard strikes available from stock, or custom designed for special contour requirements.



As a plastic shelf support

. . . with the heart of steel for extra strength. Millions now used by all major refrigerator manufacturers. Complete flexibility of head design.

What is <u>your</u> application for

SPRING-LOCK?

Send us your application inquiries. Our engineers will answer you specifically and promptly. Or, write today for the Simmons Catalog. SPRING-LOCK samples are available upon request.

SIMMONS FASTENER CORPORATION

1756 North Broadway, Albany 1, New York

QUICK-LOCK • SPRING-LOCK • ROTO-LOCK LINK-LOCK • DUAL-LOCK

See our 8-page catalog in Sweet's Product Design File.

Precision Molded Thermoplastics

by Quinn Berry

Here's a clear picture of Quinn-Berry versatility . . . two widely different molded thermoplastic components for The Sessions Clock Company of Forrestville, Connecticut:

1. The beauty of the simple precision molded thermoplastic "Sweetheart" case for Sessions revolutionary "Love Alarm" . . . a gentle "purring" beneath the pillow to awaken only one sleeper while the other sleeper sleeps. Simplicity itself!
2. Precision molded in one piece to exacting tolerances, the nylon helical and worm drive shaft for the Sessions clock mechanism is self lubricating for long service life and accuracy of operation. Moreover, the Quinn-Berry method of molding for one piece assembly resulted in sizeable cost savings—to the manufacturer.

Each of the above components presented an individual engineering design and production challenge . . . met handily by Quinn-Berry.

Present your components requirement to Quinn-Berry where the "Unusual is Routine". You will be satisfied with the result.

CHELSEA 50, Mass.
Joseph Leader
68 Marlborough Street
Chelsea 3-3484

CHICAGO 45, Illinois
R. H. Frish
Room 211
6349 N. Western Ave.
Ambassador 2-6005

DETROIT 35, MICH.
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Diamond 1-3454

EAST ROCHESTER, N. Y.
Dynatherm, Inc.
607 West Commercial Street
Phone: Ludlow 6-0082

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2100 Ailor Ave.
P. O. Box 3207
Phone: 2-5911

MILWAUKEE 13, Wis.
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7105 Grand Parkway
Greenfield 6-7161

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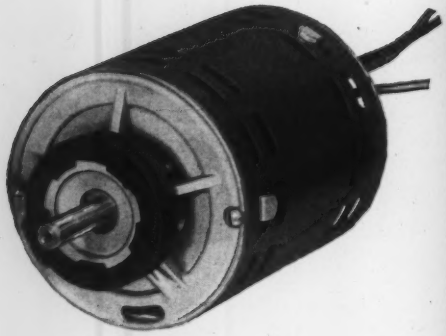
WE FLY TO SERVE YOU FASTER!

QUINN-BERRY

2609 WEST 12TH STREET, ERIE, PA.



this R & M motor puts the "Drive" in IBM electric typewriters!

Almost twelve years have elapsed since International Business Machines Corporation used its first R&M motor to power its electric typewriters. Since then R&M has supplied thousands upon thousands of these special motors for IBM's world-wide typewriter trade. In order to meet varying electrical conditions the world over, they are now supplied in 21 different voltages and frequencies.

IBM proposed strict requirements for powering their machine. The motor must have high starting torque for quick response . . . run very quietly . . . cooler than normal . . . fit a limited space . . . and have stamina to perform dependably year after year. Within a short period of time, R&M delivered specifications for the right design—a dynamically balanced motor that fulfilled all of IBM's standards, including reliable operation that covers thousands of hours between check-ups.

A lot of fingers have gone over the keys since R&M produced its first IBM typewriter motor, but we still subject each IBM power unit to 100% inspection. Moreover, we constantly work with IBM—and all our customers—to improve our motors and to adapt them to the ever-changing requirements of customers' products.

R&M's experience in custom-designing motors for hundreds of products, and our facilities to produce a design at low cost, are at your service. Perhaps your problem can be met with a standard *"off-the-shelf"* power unit. If so, we'll tell you . . . and recommend the right R&M motor for the job. For power by either custom or standard fractional HP motors . . . and performance that will give you a big competitive advantage . . . get in touch with Robbins & Myers today! Write for Bulletin No. 450-MD

ROBBINS & MYERS, INC.

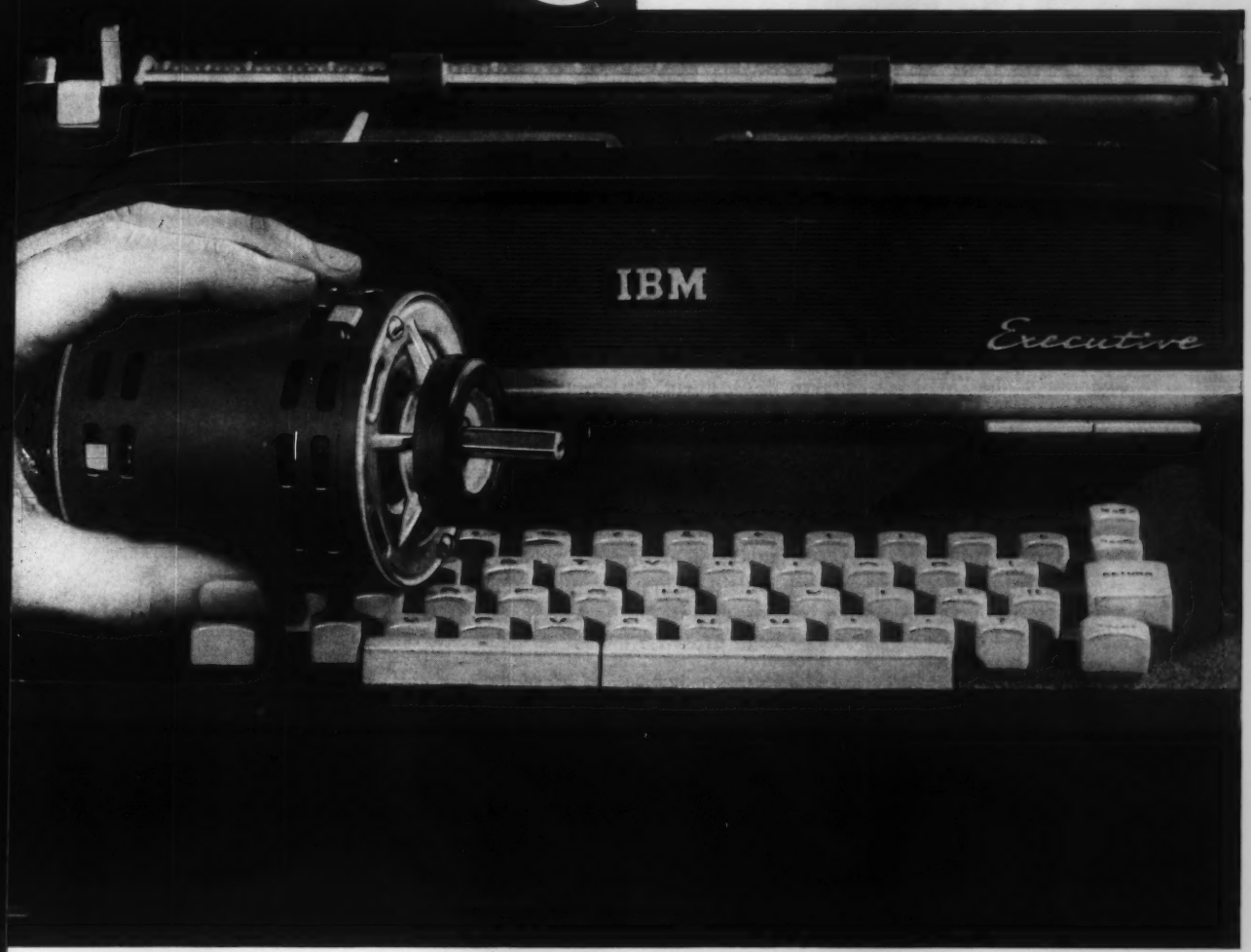
motors, household fans, Propellair industrial fans, hoists, Moyno industrial pumps

SPRINGFIELD, OHIO • BRANTFORD, ONTARIO

Circle 478 on Page 19

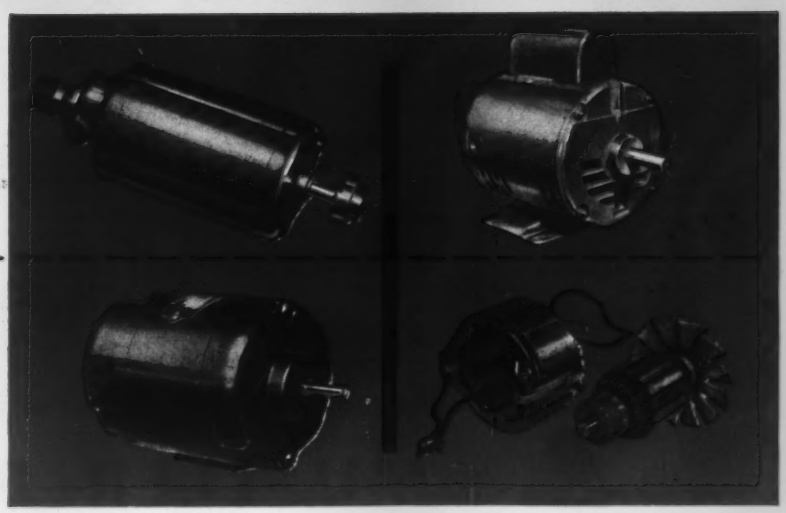
MOTORS 1/200 thru 1 HP

(other ratings up to 200 horsepower)



At left, Retractable Capstan Motor . . . shaft of this special R&M fractional HP motor rotates and also moves axially. Manufactured for IBM's 727 Magnetic Tape Unit.

At right, Standard Fractional HP Motors . . . a wide range of types, sizes and mountings for DC, single or polyphase AC; all standard voltages and frequencies.



At left, Standard Universal Motors . . . ratings from 1/50 to ½ HP. Choice of end, pad or foot mountings to permit design versatility. Custom designs also available.

At right, Series Motor Parts . . . precision-made series, universal or polyphase high-cycle motor parts. All types and sizes engineered to your requirements.

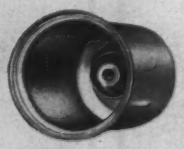
MUELLER BRASS CO. OFFERS 7 WAYS TO PRODUCE YOUR PART

Mueller Brass Co., because of its diversified manufacturing facilities that encompass a wide range of fabricating methods, is in the unique position of being able to offer you, the purchaser, an intelligent, unbiased analysis and recommendation of the best, most economical method by which your particular part can be produced. As the result of over 40 years' experience, the "Methods Analysis Department" has at its command complete knowledge of the advantages and limitations of each production process. After receiving detailed knowledge concerning the end use of the part, material specified, conditions under which it must operate and other pertinent factors, these analysis engineers make their recommendations. Every detail is considered. In many cases, methods analysis engineers recommend a simple design change that makes practical a much more economical method of production. This technical service, offered only by Mueller Brass Co., is given to each individual inquiry and is your assurance that you will get the best product at the best price . . . made the *one* best way . . . by Mueller Brass Co.

Send today for free technical literature on any one or all of the seven fabricating methods.

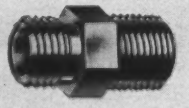
FORGINGS

Production equipment is available to produce press, hammer or cored forgings of any practical shape in sizes ranging from a few ounces to 150 lbs. in brass, bronze, aluminum and magnesium in 27 standard, as well as special, alloys.



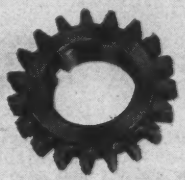
COLD-PREST® IMPACT EXTRUSIONS

Mueller Brass Co. has complete machinery for producing Cold-Prest impact extrusions of aluminum, copper, brass, bronze and steel. Extrusions up to 28" in length are possible, depending on wall thickness and other design details. Parts can be designed having ribs, flutes, splines or bosses . . . with multiple wall diameters and with uniform or tapered wall sections.



SCREW MACHINE PRODUCTS

Mueller Brass Co. has one of the world's largest automatic screw machine departments fabricating both ferrous and non-ferrous custom parts. We can produce an infinite variety of shapes and sizes from ⅛" to 3¼" in wide range of free cutting and specialized alloys. Complete facilities for all secondary and finishing operations, as well.



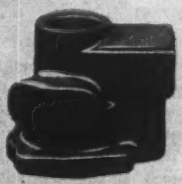
POWDER METAL PARTS

Mueller Brass Co. can supply precision Sinteel® powder metal parts in wide range of sizes and metals at high production rate. Parts available from iron, brass and copper alloys. Parts may be ordered with such characteristics as self-lubrication, controlled porosity and good electrical and magnetic properties.

MADE IN U.S.A. TO THE STANDARDS OF AMERICAN INDUSTRY

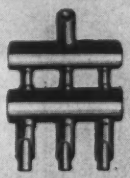
MUELLER BRASS CO.

...and our methods analysis service helps you determine which is the best ...and most economical method



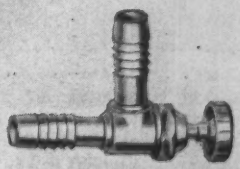
SAND CASTINGS

We specialize in the production of pressure-tight red brass castings. We utilize both metal match plate and wood patterns. Facilities include tool room and pattern shop, electric melting furnaces, high capacity core room and both bench and floor molding equipment to handle wide range of sizes.



FORMED COPPER TUBE

Mueller Brass Co. has modern facilities for forming seamless copper tube into a multitude of shapes. Forming methods used include bending, spinning, expanding or swedging, upsetting, flaring, flattening, beading and grooving, drilling and piercing, machining and joining. Formed copper tube coils are also available as single, double, spiral and serpentine shapes.



PLASTIC INJECTION MOLDING

Injection molding of plastic parts is still another process offered by the Mueller Brass Co. Parts are molded from such plastics as—nylon, polyethylenes, polyvinyl chloride, styrenes, linear acetal, chlorinated polyether, polycarbonates or polypropylene, dependent on part application.

MAN FROM MUELLER BRASS CO.

Since only Mueller Brass Co. can produce your part by all these methods, only the Man From Mueller Brass Co. can give sound advice on the one best method of production. Over 40 years of research, engineering, manufacturing and marketing experience stands behind him. When you are specifying and purchasing fabricated metal parts, call in the MAN FROM MUELLER BRASS CO.

271

PORT HURON 20, MICHIGAN

Nature's Tiny Flashlight. There's more to the surprisingly bright flashes of the firefly (*Lampridae*) than the body chemicals which it burns. In addition, a clear, curved section of the insect's skin acts as a magnifying lens and a layer of crystals as a reflector.

Miniature Angle Counter. Moving tape on this counter used in aircraft (approx. 3½″ long) shows horizontal angular deviation from pre-set point. MPB bearings on key shafts help keep torque at approximately 0.1 ounce-inch at temperatures from −55°C to +125°C!

Man with Miracles. Chuck Sheridan is constantly helping industry and aviation to solve problems of friction and inertia with MPB bearings. Like all MPB Technical Representatives, he'll be glad to help you meet the challenge of miniaturization efficiently and economically.

New Miracles in Miniaturization

ACTUAL SIZES OF BEARINGS USED IN ANGLE COUNTER SHOWN ABOVE

Today's accelerated processing programs (and space programs) demand that equipment operate continuously and faultlessly at high rates of speed and with maximum efficiency. The bearings which minimize frictional and inertial losses in such equipment must often be extremely small, but nonetheless dependable in every respect. MPB supplies industry and the military with tiny, tough, reliable bearings from a line of 500 types and sizes ranging down to 1/10″ O.D. "Specials" when necessary. For complete details, ask for our new catalog. Engineering assistance on request. Write **Miniature Precision Bearings, Inc.,** 110 Precision Park, Keene, N. H.

MINIATURE PRECISION

MPB

BEARINGS, INC.

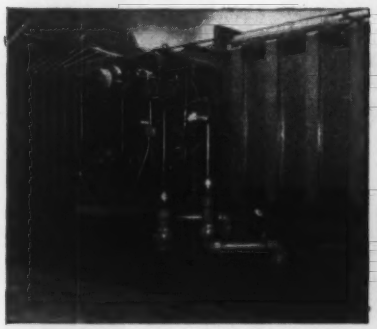
Helps you perform miracles in miniaturization

Circle 481 on Page 19

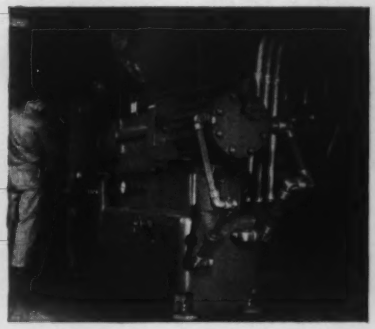
ON EQUIPMENT LINES ■

CHIKSAN SWIVEL JOINTS

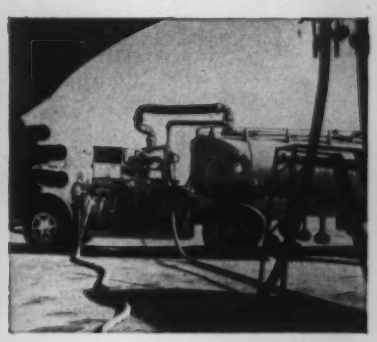
team up strength + flexibility + endurance...



QUICK DISCONNECT FOR A SUPERSONIC WIND TUNNEL—On lines that require frequent disconnecting, such as on this wind tunnel, Chiksan swivel jointed assemblies, teamed with Weco Unions, disconnect quickly, swing out of the way and then back into perfect alignment. **For application details, request report 008.**



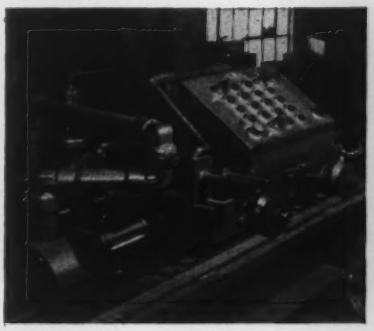
0 TO 2000 PSI IN ONE SECOND—injection molding machine lines must be flexible. Safety is a must. Endurance highly desirable. Chiksan Swivel Joints not only fulfilled these important requirements but their savings in replacement cost soon paid for the swivel joints. **For applicable details request report 001.**



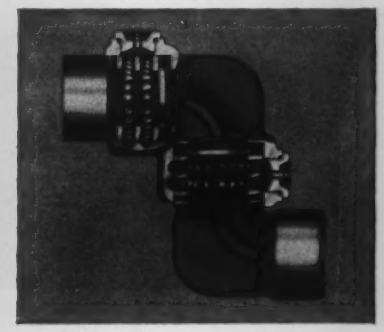
SAFETY LINK FOR JET-FUEL DELIVERIES—In design of trailer tankers for fueling jet aircraft one danger point was the suction line from pump to the trailer. By employing Chiksan Swivel Joints desired flexibility was maintained and the danger of kinking was eliminated. **For application details request report 006.**

When moving machine parts cause tight bend or twist on hose lines, Chiksan Swivel Joints are a ready solution. Or when your design dictates the use of flexible metal lines, Chiksan Swivel Joints allow controlled flexibility. Whenever line endurance, strength and flexibility are desired Chiksan Swivel Joints may offer a ready solution.

Chiksan Swivel Joints with their infinite service life, full 360° rotation and high safety factor, quickly pay for themselves by minimizing hose replacement and by eliminating costly line failure, fluid loss and downtime. For expert advice on your line design problems contact Chiksan. A nearby representative will call, analyze your requirements, and make specific recommendations.



ON THE MOVE 24 HOURS A DAY—Every five seconds right around the clock this machine tests finished pipe with water under pressures up to 1000 psi. Line movement is almost continuous. The solution. For safe, flexible lines of maximum endurance—Chiksan Swivel Joints. **For application details request report 010.**



DESIGN WITH SWIVEL JOINTS—Over 2,000 different types, sizes and styles give you an excellent selection of swivel joints for your design application.

Send for illustrated literature ➡

CHIKSAN COMPANY, 330 North Pomona Ave., Brea, California

☐ Please send me your latest General Catalog
Please send me product application report ☐ .001 ☐ .006 ☐ .008 ☐ .010

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A SUBSIDIARY OF FOOD MACHINERY AND CHEMICAL CORPORATION

CHIKSAN COMPANY—Brea, California • Chicago 5, Ill. • Newark 2, N. J. • Weco (Division), Houston 24, Texas • Subsidiaries: Chiksan Export Co. • Chiksan of Canada Ltd.

A workman checks the contour of a wheel rim before it passes to the next, and final, forming operation. Later, the rims will be welded to the hub and drum assembly to make the complete wheel.

Automobile wheels - a torture test for sheet steel

What a beating the wheels on your automobile must take! And how doggedly they stand up under their gruelling ordeal! Surely this is dramatic proof of the invincibility of strong sheet steel.

But the true torture test of steel sheets takes place in the actual making of the wheels themselves. Take rims for example. Here, the tough, strong sheet must be ductile enough to be spun to the complex contour required. It's no doubt one of the toughest tests imposed on steel sheets anywhere. Only top-quality sheets—like Bethlehem's—will take such severe punishment with uniform success.

Bethlehem sheets have been formed into hundreds of thousands of wheels for leading makes of automobiles. We'll gladly discuss your sheet steel needs, whenever it suits you. Just call our nearest office.

BETHLEHEM STEEL COMPANY, BETHLEHEM, PA.

Export Distributor: Bethlehem Steel Export Corporation

BETHLEHEM STEEL

BETHLEHEM STEEL

DESIGN BREAKTHROUGHS

in fastener engineering

One of the earliest and most basic breakthroughs in fastener design was the common clothes pin. And, although DOT is not a manufacturer of clothes pins, many a DOT industrial fastener has had an equally revolutionary effect on modern fastening technique. Hundreds of different DOT fasteners have created relatively minor revolutions in specific industries.

A DOT fastener may save a few man-minutes of labor. It may save material. Or it may improve product performance and hence saleability. But multiply each small improvement by the number of units in a true mass-production operation and the savings really pile up to impressive proportions.

Rather than spend your own design staff's time on fastening problems, it might pay you well to call in DOT. You'll have at your service a design and production organization with large-scale facilities for genuine mass-production of special-purpose fasteners and self-fastening devices of all kinds.

Supplementing the Carr Fastener Company are a number of other plants which form the United-Carr Fastener group. They are located in the principal production centers of the United States, Canada, England and Australia. Your nearest United-Carr field office (see below) is no further away than a telephone call from your desk.

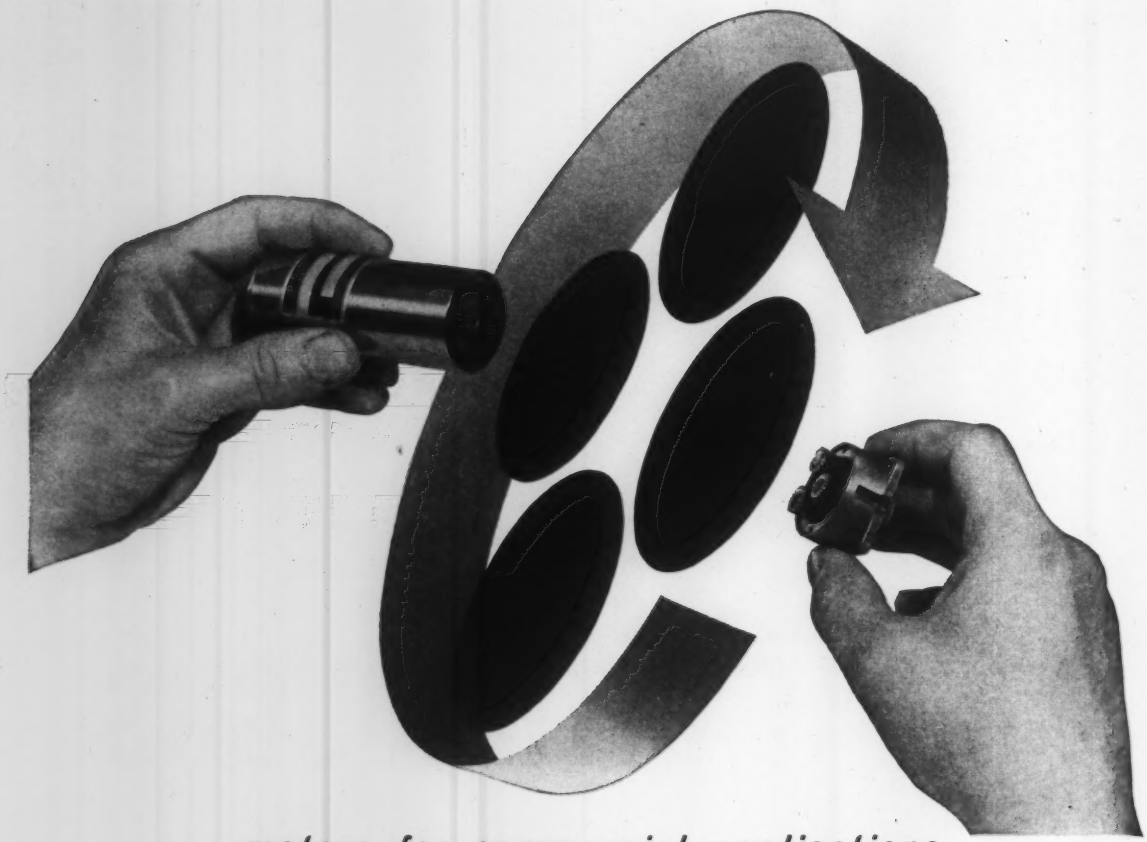
MAKERS OF ★ DOT ★ FASTENERS

CARR FASTENER COMPANY

Division of United-Carr Fastener Corporation • Cambridge 42, Massachusetts

Offices In:

Atlanta, Boston, Chicago, Cleveland, Dallas, Detroit, Los Angeles, New York, Philadelphia, Syracuse



motors for commercial applications

HIGHEST TORQUE FOR SMALLEST SPACES

Missile designers are well acquainted with the extremely high torque available from a planetary geared precision miniature Globe motor. Units similar to the one pictured can produce up to 150 inch pounds of torque!

And more and more designers are finding that these motors offer outstanding advantages for commercial applications as well. Universal, a.c., or d.c. types are available from 7/8" to 2 1/4" in diameter. They can replace larger, ordinary motors at competitive cost, and deliver important bonuses too. They perform reliably under conditions that would soon ruin ordinary motors—high humidity and temperature, jarring shock and vibration, dust and fume-laden atmospheres.

Globe speed reduced motors are engineered to fit your specific application as no "off the shelf" motor can. Standard component design is the secret; for example, 83 even ratio planetary reducers are available to give the speed and torque you need. Many parts are inventoried. Design and production efficiency will save you money. If you have a commercial application that demands a smaller, more powerful, more reliable and competitively priced motor, then consult Globe first. Write for Bulletin ACG. Globe Industries, Inc., 1784 Stanley Avenue, Dayton 4, Ohio.

GLOBE INDUSTRIES, INC.

PRECISION MINIATURE A.C. & D.C. MOTORS, ACTUATORS, TIMERS, GYROS, STEPPERS, BLOWERS, MOTORIZED DEVICES

GLOBE

WHY DID THIS BOLT FALL OFF?

Where is the culprit . . . the nut whose function was to keep the bolt securely in place? Undoubtedly it fell off earlier . . . loosened by vibration . . . or unexpectedly high shock loads due, perhaps, to a careless operator. In any event, the bolt was pounded into uselessness . . . and failed. Chances are that the equipment the bolt and nut were part of is temporarily useless too.

Why then, was an inadequate fastener applied in the first place? Perhaps because "bolts and nuts" are often overlooked or specified routinely. Perhaps to save a fraction of a cent. Whatever the reason, the end result was inefficient and uneconomical. The nut failed—the fastening failed—and the product failed.

It could have been prevented. An Elastic Stop® nut would have held on. The small extra cost of the *best* self-locking nut would have solved this case . . . saved repair bills . . . downtime . . . and a manufacturer's reputation.

For detailed photos showing how some of America's foremost manufacturers of heavy equipment have insured critical bolted connections with Elastic Stop nuts on such units as rock drills, scrapers, snow plows, off-the-road trucks . . . write to ESNA. Or, for first hand proof, tell us the preferred size and we'll send you test samples. Address: Dept. S35-104, Elastic Stop Nut Corporation of America, 2330 Vauxhall Road, Union, New Jersey.

DOUBLE DEPENDABILITY

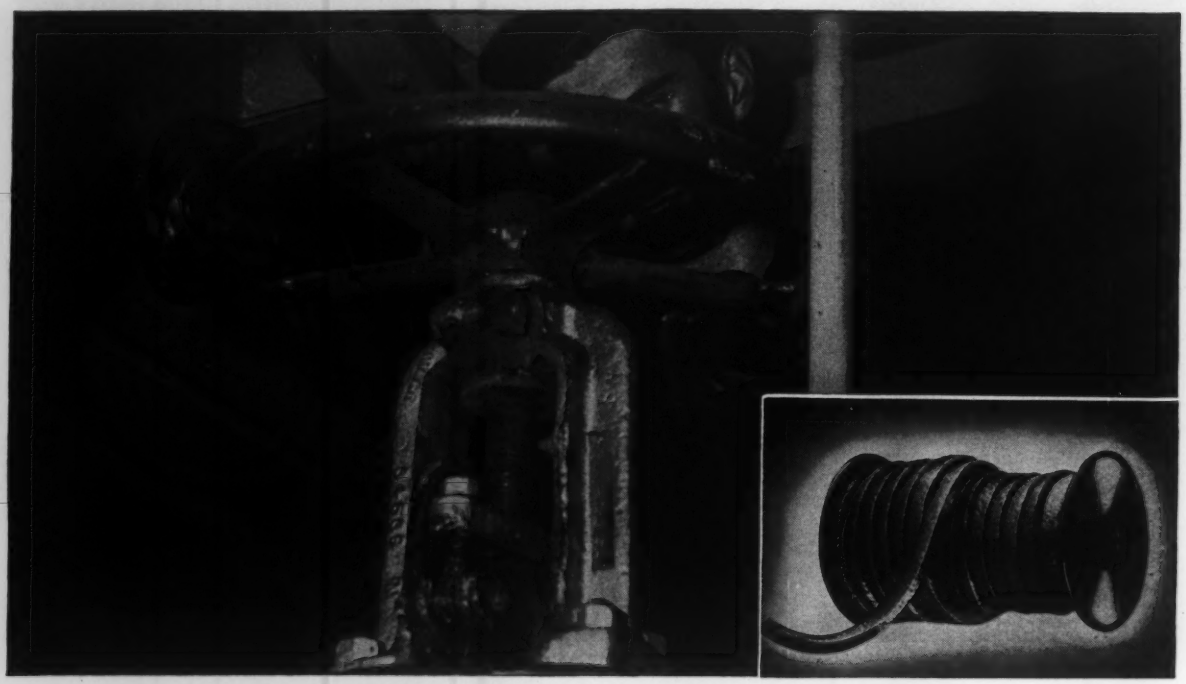
The dependability built into every Elastic Stop nut builds itself into the dependability of every product on which it is used.

ELASTIC STOP NUT CORPORATION OF AMERICA

CUT COSTS, IMPROVE DESIGN AND PERFORMANCE WITH R/M PRODUCTS

PACKINGS

Complete information on the packings shown and many others is given in free booklet. Send for it today.
Packing Division, Raybestos-Manhattan, Inc.
Passaic, N.J.



Recommended for hot oil and high pressure steam: R/M High Temperature Valve Stem Packings

R/M High Temperature Valve Stem Packings—reliable solution to your hot problems

Today's boilers produce more heat and more pressure. They also produce more packing problems. To get reliable performance at temperatures as high as 1000°F or higher, specify R/M High Temperature Valve Stem Packings.

R/M's experienced engineers designed these packings to meet your toughest present and future needs. They eliminated practically all of the organic materials which break down under heat. The result is a packing which provides outstanding heat resistance and low volume loss. Solid lubricants are ground in during manufacture—you will find thorough compounding no matter where you cut into the packing. R/M uses braided asbestos—reinforced with Monel or Inconel wire to give you maximum extrusion resistance.

R/M High Temperature Valve Stem Packings are available in several types, for use with steam, hot oil, or hot gases. One of these types is ideal for your requirements. Call on the R/M engineers for their specific recommendations.

The complete R/M line includes packings and gasket sheets for use with gases, water, steam, oil, chemicals, solvents and food products. Feel free to call on R/M's experienced engineers for help in your packing problems.

R/M

Brake Blocks, Linings and Clutch Facings

Mechanical Packings and Gaskets

Abrasive and Diamond Wheels

Industrial Drive Belts

Industrial and Automotive Hose

Conveyor Belts

Circle 486 on Page 19

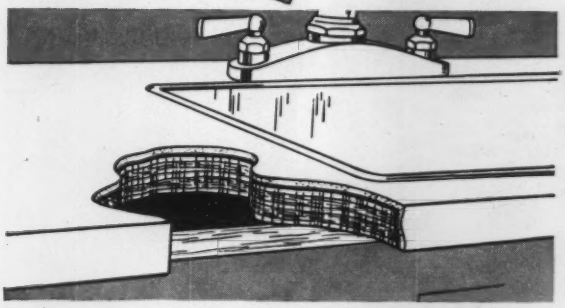
SPECIALISTS IN ASBESTOS, RUBBER, SINTERED METAL, ENGINEERED PLASTICS

ADHESIVES

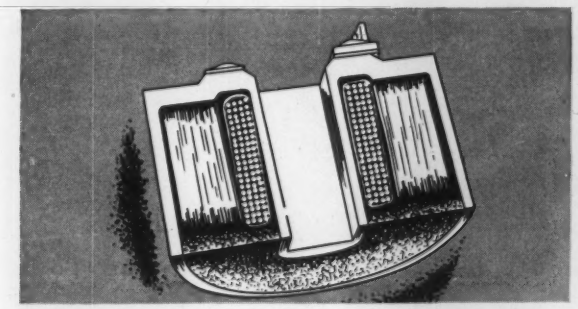
Send today for free copy of R/M Bulletin No. 700 on Ray-BOND adhesives, protective coatings and sealers.
Adhesives Department
Raybestos-Manhattan, Inc.
Bridgeport, Conn.

RUBBER

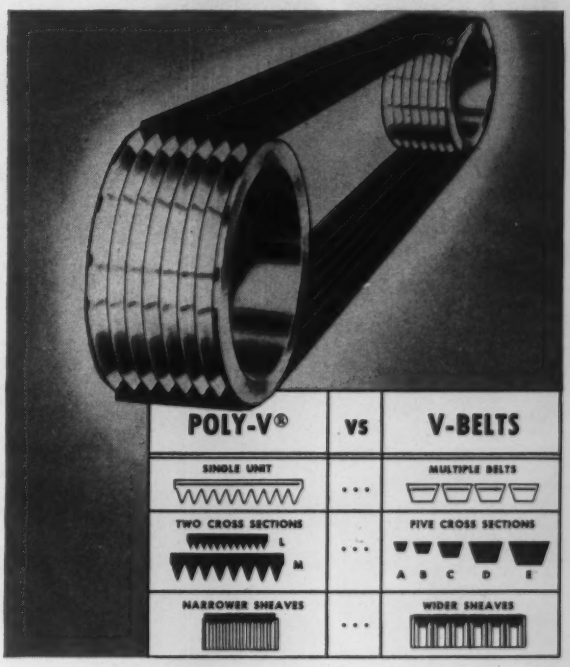
Write today for free booklet shown: full details on a wide variety of industrial rubber products.
Manhattan Rubber Division
Raybestos-Manhattan, Inc.
Passaic, N.J.



Bonding cabinet top to base



Sealing hundreds of wires with an R/M encapsulating compound



R/M Ray-BOND® Adhesives for faster production—lower costs

Ray-Bond Adhesives, tailored to the performance needs and the fabrication techniques of the individual manufacturer, are meeting widely varied requirements in products as diverse as aircraft engines and submarine cables, band saws, textiles and other porous materials. Adhesive bonding can cut your assembly costs, speed production, and simplify fabrication problems. It eliminates rivets and other fasteners, provides better heat conductivity, increases the life of friction members, and permits more effective bonding of dissimilar materials.

R/M offers you the benefit of its more than 20 years of experience with bonded assemblies for varied applications. Feel free to call on our engineers for help.

Put more power in less space with R/M Poly-V® Drive

Unique design of its single, parallel V-ribbed belt gives R/M Poly-V Drive* *twice* the tractive surface of a conventional multiple V-belt drive. This means Poly-V delivers up to 50% more power in the same space as a V-drive or equal power in as little as ⅔ the space! R/M Poly-V permits a more compact, lighter weight drive with less shaft overhang. Just two belt cross sections meet *every* heavy duty drive design requirement.

For light duty, single groove drive applications specify R/M FHP V-belts. Patented micro-positioned strength member and density controller make these the smoothest running V-belts made. Run quieter, cooler—and with less vibration. They're ideal for all kinds of motorized appliances, pumps and power tools. Whatever the drive design problem, rely on R/M specialists for the solution.

*Poly-V is a registered Raybestos-Manhattan trademark.

RAYBESTOS-MANHATTAN, INC.

FACTORIES: Passaic, N.J. • Bridgeport, Conn. • Manheim, Pa. • Paramount, Calif. • No. Charleston, S.C. Crawfordsville, Ind. • Neenah, Wis. • Peterborough, Ontario, Canada

Rubber Lined and Covered Equipment

Sintered Metal Friction Elements

Asbestos Textiles

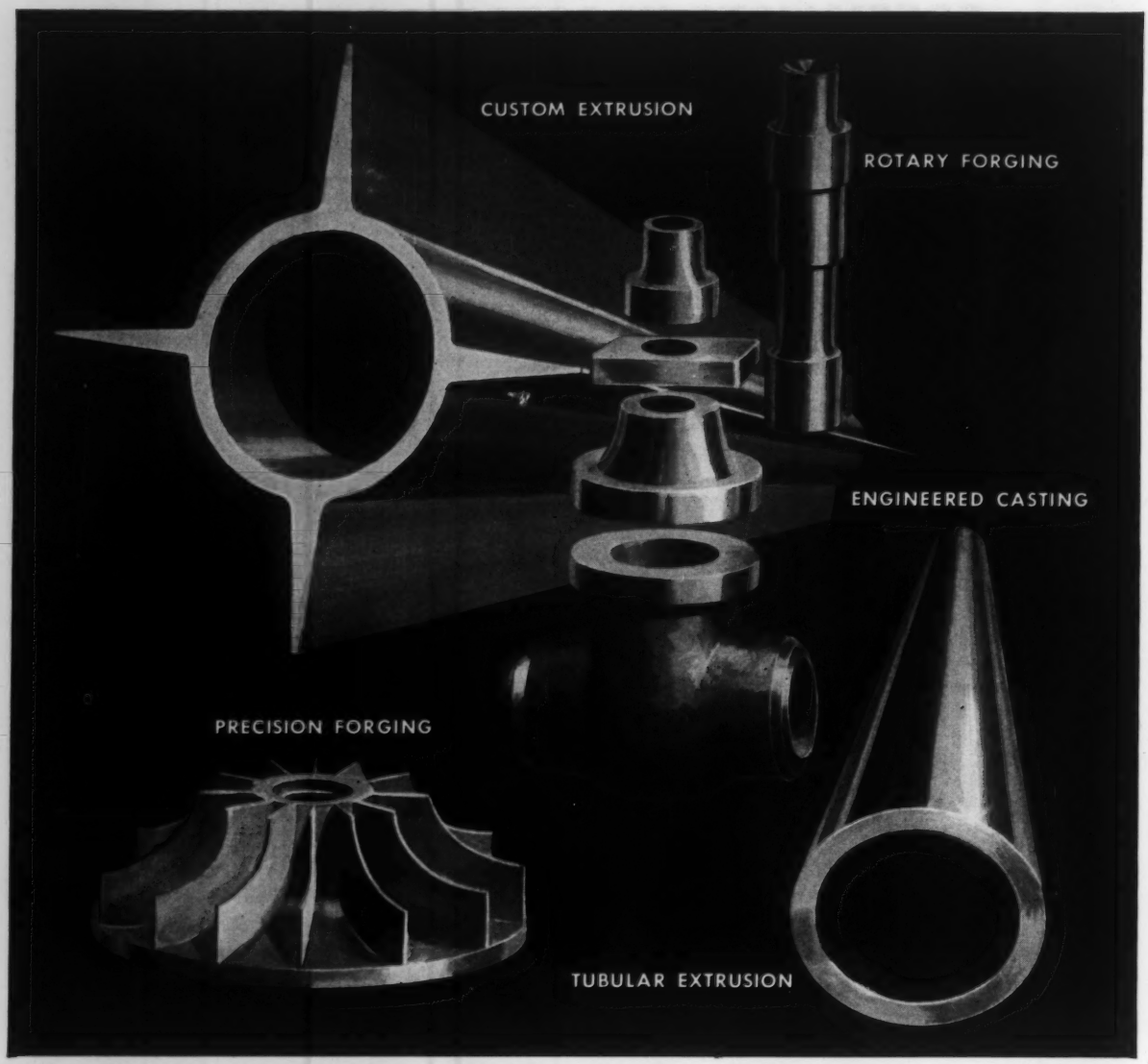
Industrial Adhesives

Teflon Tape, Packings, Sheets, Rods, Tubes

Engineered Molded Rubber and Plastics

Circle 487 on Page 19A

Circle 488 on Page 19A



CURMET premium quality works for you in products like these

Curtiss-Wright Metals Processing brings out the best that an alloy can offer—steps up the performance of forgings, castings and extrusions—helps underwrite the performance of your product in use.

For example, exclusive CURMET rotary forging places the metal where it is designed to be on a stepped shaft, reducing chip production cost up to 50%. CURMET ceramic mold casting reproduces so closely to blueprint that non-machinable alloys can be cast, giving your product far greater wear resistance.

This is true with each of the CURMET precision methods for shaping hard-to-work metals. Further, production facilities are integrated . . . the large 40-foot stainless steel extrusions you require can be delivered heat treated to optimum strength level, the close-tolerance forgings you need can be finish machined and assembled . . . all within the CURMET one-source service.

To strengthen your product or process by putting premium quality to work for you, call the nearest CURMET representative or write for full information.

Visit us at booth 1730, National Metals Exposition, Chicago, Nov. 2-6

CURTISS-WRIGHT CORPORATION
METALS PROCESSING DIVISION
71 GRIDER STREET
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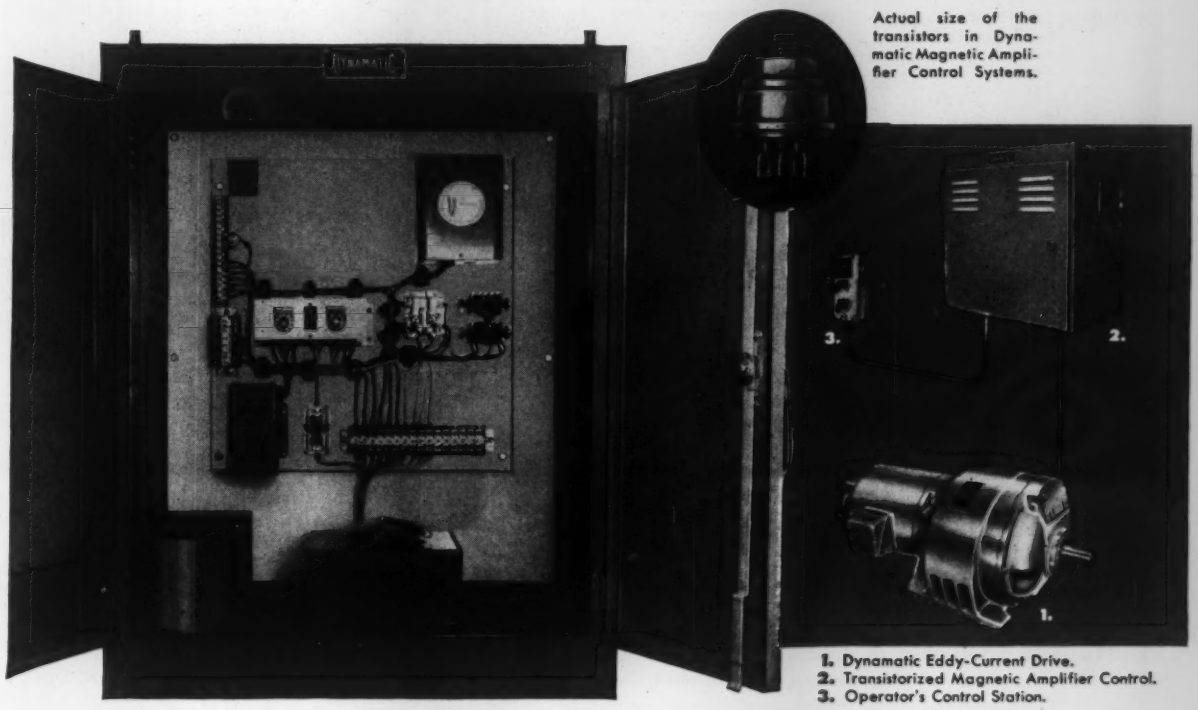
NEW RELIABILITY!

DYNAMATIC®

MAGNETIC AMPLIFIER (TRANSISTORIZED) CONTROL SYSTEMS

for Eddy-Current Rotating Equipment



Actual size of the transistors in Dynamatic Magnetic Amplifier Control Systems.

1. Dynamatic Eddy-Current Drive.
2. Transistorized Magnetic Amplifier Control.
3. Operator's Control Station.

DYNAMATIC Transistorized Magnetic Amplifier Control Systems are based on a new principle using rugged electrical components designed to provide many times the life of components used in electronic speed control systems. Transistors, reactors, and silicon rectifiers take the place of vacuum tubes; there are no wearing parts to require maintenance, adjustment, or replacement. These transistorized controls are ideal for installation in remote areas and for unattended operation.

Used in combination with Dynamatic Eddy-Current Drives, Transistorized Magnetic Amplifier Controls provide infinite speed adjustment and accurate control for almost any application from five through 10,000 horsepower. Three essential components—drive, push-button station, and magnetic amplifier control—make up the Dynamatic Drive Package, which operates on alternating current. Standard control features include constant speed regulation, infinite speed adjustment, on-off clutch control, and jogging. Special features may be easily added to standard controls to meet the requirements of individual applications.

Dynamatic Transistorized Magnetic Amplifier Control Systems provide a high degree of accuracy and versatility—and are practically maintenance-free.

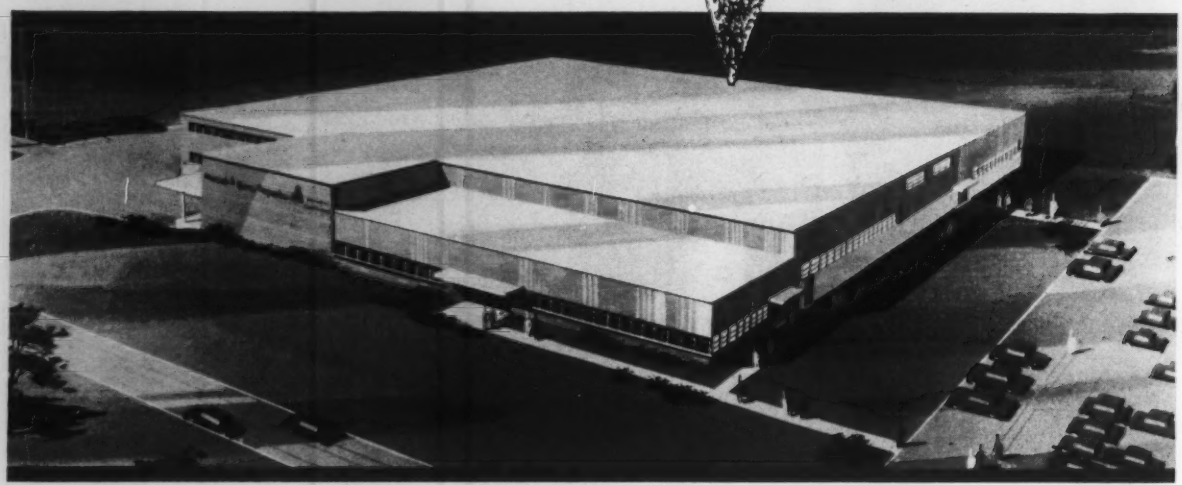
Send for New Illustrated Bulletin Describing Circuitry, Construction, and Operation.

EATON®

DYNAMATIC DIVISION
MANUFACTURING COMPANY
3307 FOURTEENTH AVENUE • KENOSHA, WISCONSIN

Circle 490 on Page 19

"Build us a plant,". . . we said, "to step up spring service to the mid-continent"



and here it is . . .

newest, most modern springmaking plant in the world

Ground broken in June . . . now beginning operation . . . this modern plant of our Gibson Division means improved quality, production efficiency and customer service — the prime objectives of Associated Spring Corporation. In the mid-continent region, for example, we now provide in addition to this plant, a new sales and engineering office in Chicago, plus expanded operations in the Milwaukee Division.

Here is further evidence of adapting to needs of industrial markets—already demonstrated in the strategic location of other Associated Spring Divisions and sales offices throughout the United States, Canada and Puerto Rico. It's also assurance of progress, stability, and responsibility that you expect from the leader in precision mechanical springs and small stampings.

5912

Associated Spring Corporation — **General Offices: Bristol, Connecticut**

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Gibson Division, Mattoon, Ill.
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Milwaukee Division, Milwaukee, Wis.
Ohio Division, Dayton, Ohio
Raymond Manufacturing Division, Corry, Penna.
Cleveland Sales Office, Cleveland, Ohio
Seaboard Pacific Division, Gardena, Calif.
San Francisco Sales Office, Saratoga, Calif.
B-G-R Division, Plymouth and Ann Arbor, Mich.
F. N. Manross and Sons Division, Bristol, Conn.
Dunbar Brothers Division, Bristol, Conn.
Wallace Barnes Steel Division, Bristol, Conn.
Subsidiaries—Wallace Barnes Co., Ltd., Hamilton, Ont. and Montreal, Que.
Associated Spring of Puerto Rico, Inc., Carolina, P.R.

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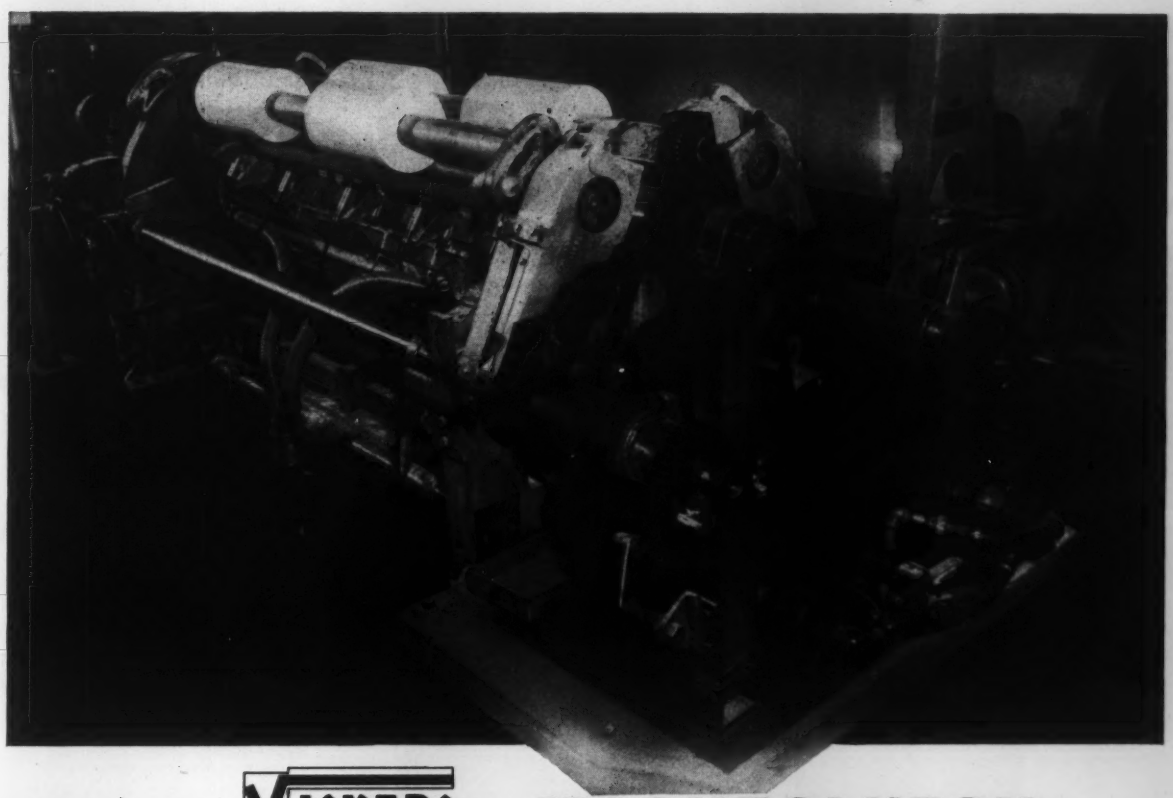


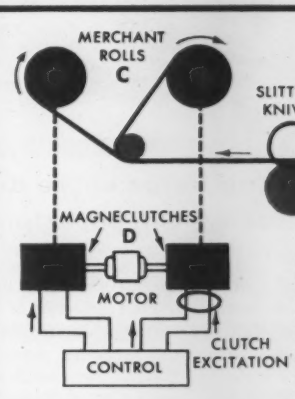
How the VICKERS® MAGNECLUTCH® CONTROLS TENSION...PREVENTS BREAKDOWN on this high-speed paper slitting machine

The smooth, trouble-free operation of this slitting machine of a well-known paper converter demonstrates another practical use of the Vickers Magneclutch, the dry magnetic particle clutch.

Two water-cooled, 200 lb-ft, 6-2-6 Magneclutches maintain uniform tension on the fast-moving web as it is unwound, slit and rewound. Strain, breaking or snarling of the paper is eliminated, downtime is prevented.

The Magneclutch is designed to provide precise regulation and transmission of torque, without grab or chatter. Torque responds quickly, is unaffected by temperature or humidity; water-cooled design dissipates slip heat rapidly; and since there is no wear on torque transmitting surfaces, service life is extremely long. Torque transmission, regulated by energizing current only, is independent of speed, and is easily and remotely controlled.

Write for Descriptive Bulletin on The Vickers Magneclutch



Paper is pulled from parent roll A, fed through slitting knives B, and rewound on merchant rolls C. As the merchant roll diameters increase, additional windup torque needed is provided by increased electrical excitation of the Magneclutches D. Clutches slip to maintain constant web speed and tension.

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VICKERS INCORPORATED
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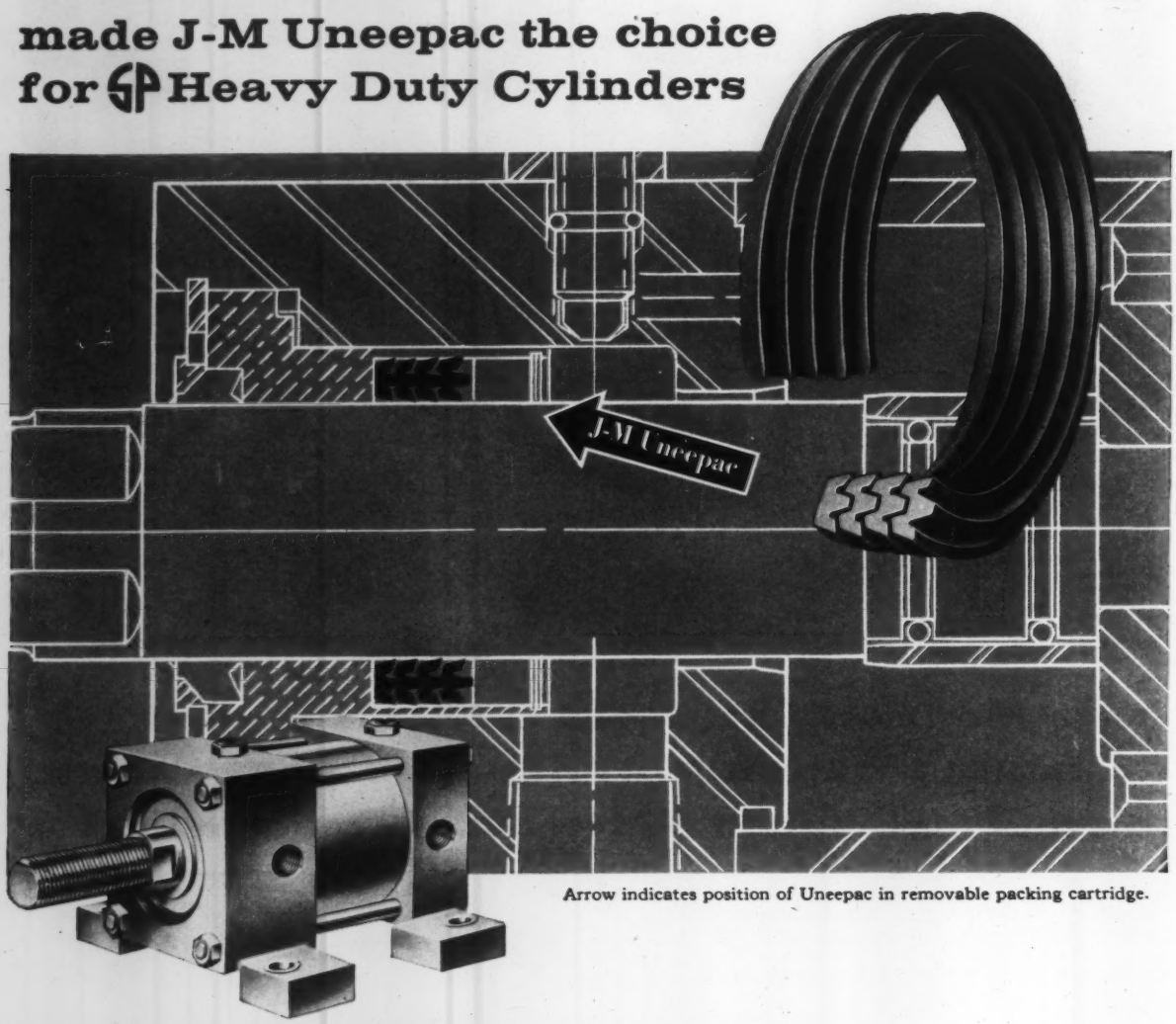
Compactness...

made J-M Uneepac the choice for S-P Heavy Duty Cylinders



Arrow indicates position of Uneepac in removable packing cartridge.

Automatic ring packing helps solve design problem for the S-P Manufacturing Corporation of Solon, Ohio

THE INCREASING TREND toward automation in industrial processes has been made possible by the development of dependable service-free equipment like S-P Heavy Duty Cylinders. Among the design features which make S-P Cylinders so reliable are two Johns-Manville precision moulded packings.

J-M UNEEPAC® automatic ring packing provides maximum sealing in minimum space because each ring is a complete packing unit. This permits an overall reduction of the cylinder size and, in particular, enables S-P to include a quick-change removable packing cartridge. Uneepac is also self-adjusting—each ring positions itself automatically on adjoining rings. Friction is low because when assembled in sets, fluid pressure acts upon each lip individually. Lip section is also well supported to prevent distortion under pressure.

J-M U-CUPS are also used in the S-P Cylinder as piston head packing. They are precision-made for easy assembly, accurate fit, efficient sealing, reduced friction and long life.

Uneepac and U-Cups are made in a variety of compositions for a wide range of hydraulic and pneumatic applications. For further information, write to Johns-Manville, Box 14, New York 16, N. Y. In Canada, Port Credit, Ontario.

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JOHNS-MANVILLE JM PRODUCTS

Circle 493 on Page 19

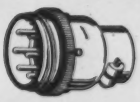
cam-7-line

27,000 CANNON PLUG DESIGNS

FOR EVERY CONCEIVABLE APPLICATION

AIRCRAFT AND ELECTRONIC INSTRUMENTATIONS—MS, MS-A, MS-B, MS-E, MS-R SERIES, conforming to Specification MIL-C-5015D. Vibration-proof—Lightweight—Plugs are available with from 1 to 100 contacts. 15 different insert diameters and 260 contact layouts. 6 shell styles, MS 3100 to MS 3108 with all accessories. Environmental-Resisting MS-E and MS-R Series have interfacial sealing at mating faces and integral grommet seal at wire entry plus—grounding lugs and integral cable clamp.

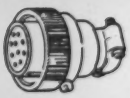
GENERAL CIRCUITRY AND QUICK DISCONNECT—K, RK SERIES, with special acme thread. The all-purpose series with eight insert diameters available. Conduit and cable clamp entry types. 1 to 110 contacts. 10, 15, 30, 40, 60, 80, 115 and 200 amp. silver plated contacts. High quality phenolic, melamine, and formica insulators. Cadmium-plated aluminum alloy shells.



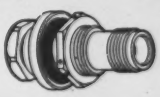
UNIT-PLUG-IN RACK/PANEL-DP, DPB, DPD, DPDZ, DPD2R, DPJ, DPS SERIES, available with from 2 to 180 contacts in rectangular inserts. With and without shells; coaxial and high voltage contacts. Permit quick disconnect, interchange, replacement, testing, and inspection of assemblies and sub-assemblies.

AUDIO AND LOW-LEVEL CIRCUITS—P, XLR, XK, O, UA, BRS SERIES, In many shell styles and insert layouts. Straight and 90° angles. Latch-lock types. Wall-mounting, panel, locknut mounting, and adapter receptacles, single and two-gang. 10 and 30 amp. contacts, coaxials.

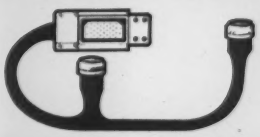
MINIATURE AND SUB-MINIATURE—D, US, DPA, DPX, AND K-MINIATURE SERIES, designed for amplifiers, miniature indicators, computer circuits, telemetering equipment, and general instrumentation of limited space requirements. Variety of shell styles, junction shells, and insert arrangements. Available with from 2 to 50 contacts, plus coaxials.



COAXIAL RF SERIES—available in a wide range of Series and types from sub-miniature to large cable applications. New Cannon adapters available for use with latest cable developments. Cannon's latest RF Plugs include aluminum versions designed for use where weight-saving is a critical design criteria.



GM AND PLUG HARNESS SYSTEMS— Cannon produces a wide range of GM Plugs to fit specific missile applications, ranging from straight umbilical dis-connects to stage-separation dis-connects. Cannon also produces Plug Harness Systems featuring MS or other specified plugs and cables as one unit, available with various contact types and sizes. From 8 to 140 contacts. Highest quality and proven reliability. Varied remote disconnect methods actuated by hydraulic, pneumatic, explosive, or manual means.



The Cannon Electric Company also has available a wide variety of plugs for Battery-Power, Fire-wall, Watertight, Printed Circuit, and other applications, as well as "Kwik-Term" Terminals and DC Solenoids.

FOR ADDITIONAL INFORMATION on the typical designs illustrated . . . other configurations for your specific applications . . . or the design, engineering and manufacture to your special needs . . . write to Cannon Electric Company—3208 Humboldt Street, Los Angeles 31, California. Please refer to Dept. 185.

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Circle 494 on Page 19

CARL S. HARVEY, *Technical Director, Lamson & Sessions, tells why...*

You overspend when you overspecify... on fasteners

Overspecifying can be costly in ordering fasteners . . . especially in view of the trend toward higher "physicals" and correspondingly higher component costs.

Here's a typical example: A customer specified AISI 1137 steel (a screw machine grade) for a nut. After a look at the "physicals" we recommended a cold forged nut of AISI 1030 steel (a straight carbon steel) and met all requirements at considerably lower cost to the customer.

In many instances we're recommending ordinary grades of carbon steel over the customer's specs of low alloy content material. Our improved heat treatment practices make the savings possible. Elementary cases, perhaps, but they happen every day!

Take Advantage of the specialized experience and facilities available to you through L&S. Leave reference to "chemistry" open. Tell us what you want in end results. Give us the "physicals" and tolerances—then stop! This helps us save *you* money, in both purchasing costs and assembly costs.

L & S Fastener Engineering helps you "tighten up" on...

- **PURCHASING COSTS**
- **INSPECTION AND HANDLING COSTS**
- **ASSEMBLY COSTS**

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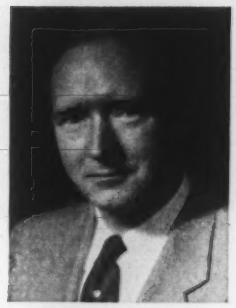
Plants in Cleveland and Kent, Ohio • Chicago and Birmingham

Circle 495 on Page 19

DESIGN
October 15, 1959



Spectator or Participant?

AS A NATION we seem addicted to "spectatoritis." As Admiral Rickover has put it, "We sit in the bleachers and let the game of life unfold before us." Sure, spectators have their place in the scheme of things: The participants do need encouragement. But those qualified to participate shouldn't be wasting all their time as spectators.

In our own field of technical communication we call the spectators "readers" and the participants "authors." We love our readers just as much as the ball team loves the fans. But we love even more those who step up to the plate or out into the field once in a while.

Our readers have the advantage over most sports fans. They all have some training in the activity they are watching. That is, they are engineers and they are literate.

A simple two-question test determines whether you belong on any team of authors. You can apply the test yourself. Here it is:

1. Do you have something worth saying?
2. Who would be interested in what you have to say?

Just as the ball team supplies the field, uniforms, equipment, and stands, the editors and publishers supply pages, layout, editing, and circulation.

You don't have to be a highly skilled writer. The editor's job is to supply the professional touch that converts an engineering-report type of document into an appealing article in which the information is accessible in ready-to-use form. But only you can supply the information.

Theodore Roosevelt once said "Every man owes some of his time to the upbuilding of the profession to which he belongs." And it is participation rather than spectatorship that builds up a profession.

Participation is lots more fun, too. Try it sometime.

Colin Carmichael

EDITOR

TABLE 1—Recommended Symbols for Geometric Tolerances

Basic Symbols

Alignment	
Angularity	
Concentricity	
Flatness	
Parallelism	
Perpendicularity or squareness	
Roundness or circularity	
Straightness	
Symmetry	
True position	
True profile or true contour	
Twist	

Qualifying Symbols

Maximum material condition (MMC)	
Regardless of feature size (RFS)	

How to simplify drawing specifications with

Symbols for Geometric Tolerances

Standardized practices for geometric and true-position tolerances are rapidly proving their worth. The next step is to streamline the drafting part of the operation and to make tolerance specs easier to read. Here's a practical proposal on how to do the job by a member of the Review Group of ASA Subcommittee Y14.5 on dimensioning and notes.

FRED L. SPALDING
Associate Professor
General Engineering Dept.
University of Illinois
Urbana, Ill.

CONVENTIONAL drafting practice with geometric and true-position tolerances is to spell out specifications in note form. Basis of this practice seems to be the general feeling that drawings should require a minimum of decoding. However, notes are often a time-consuming drafting operation and can become awkward and cumbersome to handle in certain tolerancing situations. A shorter, simplified form of notation would appear to be in order.

For uniform specification and interpretation of geometric and true-position tolerances, a simple and easily remembered ideographic series of symbols is proposed. Basic and qualifying symbols for this recommended series are given in Table 1.

Basic Concepts: Tolerance specifications consist of a symbol, the corresponding numerical tolerance value, and, if necessary, a datum reference, all enclosed in a rectangular frame, Fig. 1*a*. Frame size should be large enough to contain the required symbols, numerals, and letters without crowding. For clarity, the elements may be separated by vertical lines.

The tolerance value is always expressed as a total permissible variation, never as a half, or radial, distance. This condition may be emphasized by the addition of *DIA, TIR, TOTAL, WIDE ZONE,* or some other defining term in the frame. For simplification, use of the symbol ϕ for diameter is in common use in most foreign countries. This practice has not been widespread in the United States, but appears to be gaining favor.

The tolerance symbol frame, Fig. 1*a*, should always be placed horizontally for reading from the bottom of the drawing. Methods of connecting the

specification to the relevant feature on the part are:

1. Leader, Fig. 1*b*.
2. Extension line from the surface involved, Fig. 1c.
3. Dimension line for the feature size, Fig. 1*d*.
4. Note directed to feature, Fig. 1*e*.

The method used will depend on the type of geometric tolerance to be specified and the shape of the feature. However, the tolerance symbol frame should never be placed directly on a line of the drawing of the feature it controls.

Datum References: Tolerance specifications for parallelism, perpendicularity, angularity, concentricity, and symmetry usually involve a geometric relationship between the feature, or pattern of features, being toleranced, and another reference feature which is used as the datum.

Features selected to serve as datums must be clearly identified and easily recognizable. They must also be accessible during manufacture, and they must be more accurate than any measurements that are made from them. In some instances, tolerances of form for datum surfaces may be necessary for control in manufacture.

To avoid problems in manufacturing and inspection operations, the datum surface should always be clearly specified, unless it is perfectly obvious. In the symbol-notation system proposed here, the datum feature is identified by a capital letter pre-

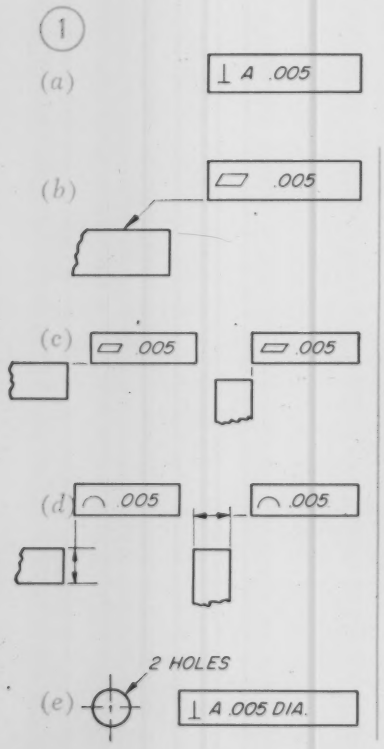
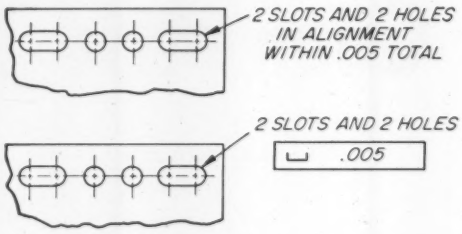


Fig. 1—Recommended practices for specification of geometric and true-position tolerances by symbol notation. General form of tolerance specification is shown at *a*. Methods of connecting specification to part feature being controlled are shown at *b* through *e*.

Alignment

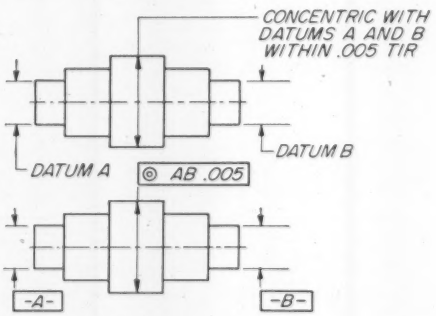
Alignment requirements may be included in specifications for parallelism, concentricity, symmetry, or other geometric characteristics. However, separate specification of alignment tolerance may be desirable in certain situations. Alignment is always in reference to two or more features, which need not necessarily be identical, or even similar. Also, alignment is always in reference to a datum, but since the datum is usually the common center line, or median plane, of the features concerned, this reference may not be necessary. In alignment specifications, conditions of feature size must always be considered; otherwise, the specified tolerances apply regardless of feature size. Therefore, where applicable, the qualifying symbol for maximum material condition should be included in the tolerance symbol frame.



Concentricity

Concentricity is perhaps the most commonly specified geometric tolerance, and yet it is probably the most difficult to express accurately and completely. Symbols will not solve the problem of correct specification of concentricity requirements, but they will simplify the application of the tolerance statement on the drawing.

Concentricity is always specified with reference to a datum. The qualification of feature size in tolerance requirements must be considered in each individual application. Unless otherwise specified concentricity tolerances apply regardless of feature size.



Parallelism, Perpendicularity, and Angularity ||, ⊥, ∠

Parallelism, perpendicularity, and angularity are all similar in that each may involve three types of geometric relationships:

1. Two plane surfaces.
2. A plane surface and either a line (such as the axis of a hole) or a series of parallel lines (such as the elements of a cylindrical or prismatic shape).
3. Two lines or series of lines.

All tolerance specifications for parallelism, perpendicularity, and angularity require a datum reference. If both datum and toleranced feature are plane surfaces, no reference to feature size is necessary. But if either the datum or the toleranced feature is not a plane surface, conditions of feature size must always be considered. Without a qualification for feature size, the geometric tolerance is to be observed regardless of feature size.

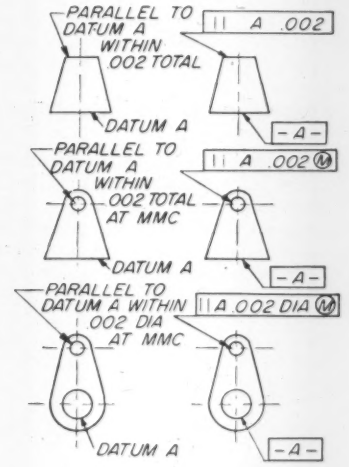
If the toleranced feature is a line, such as the axis of a hole, customary practice is to include the abbreviation, *DIA*, or the symbol, ⌀ where applicable, in the tolerance symbol frame to emphasize that the tolerance zone is equally disposed in all directions about the position of true geometry.

Typical tolerance specifications for parallelism are shown at *a*; for perpendicularity or squareness at *b*; and for angularity at c.

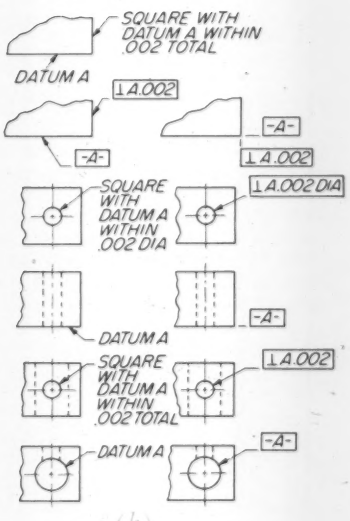
There is no generally accepted note form which distinguishes between parallelism tolerance zones which are cylindrical and those which are flat; that is, where the permissible variation from true parallelism is equal in all directions or where it is greater in one direction than in the other. However, such a requirement may be readily indicated on a drawing by symbols.

For example, two round holes in a connecting link, *d*, may be permitted to deviate from the true parallel relationship a greater amount in the direction *X* than in the direction *Y*. This requirement can be indicated by specifying the parallelism tolerance twice without the abbreviation, *DIA*, or the symbol, ⌀, in the tolerance frame, *e*. This specification means that the tolerance is in the plane of the drawing in the direction indicated by the arrowhead which terminates the line joining the symbol frame to the toleranced feature.

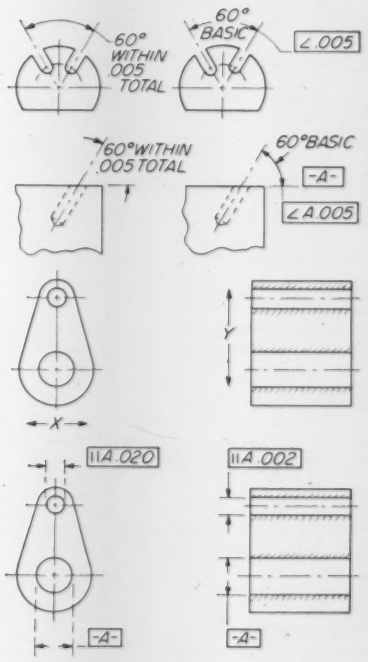
At *e*, the datum feature is the axis of hole *A* regardless of the hole size. But the permissible deviation from true parallelism is 0.020 in. in the *X* direction and only 0.002 in. in the *Y* direction, resulting in a parallelopiped-shaped tolerance zone.



(a)



(b)



ceded and followed by a dash and enclosed in a frame similar to that for the tolerance symbol, Fig. 2.

A different identifying letter is used for each datum on a drawing. Practices outlined previously for connecting tolerance symbols to part features apply also to datum references, Fig. 2. Alternative methods for associating the datum symbol with its feature are shown in Fig. 3. If only a limited portion of a part feature is to be used for the actual datum, it may be indicated by a heavy long-and-short dash line adjacent to the feature line and dimensioned independently, Fig. 4*a*. Fig. 4*b* shows a method of

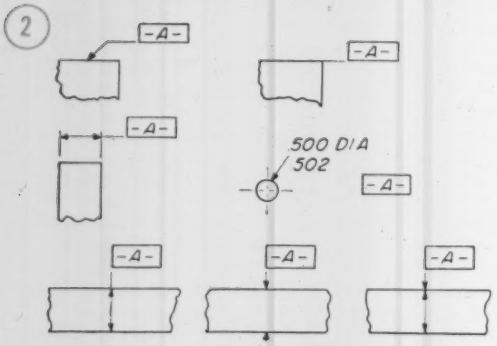


Fig. 2—Basic methods for identifying datum features in symbol-notation system of tolerance specification.

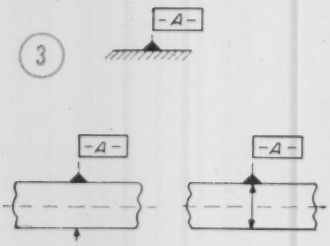


Fig. 3—Alternative methods for identifying datum features in symbol-notation system of tolerance specification.

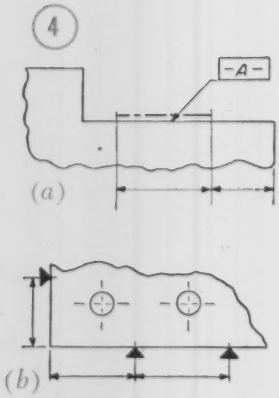
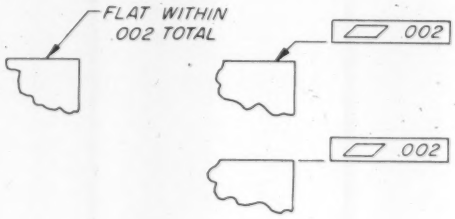


Fig. 4—Methods for identifying special datum references. At *a*, only a portion of the part feature is to be used as the actual datum. At *b*, solid triangles indicate position of points which define a possible temporary datum for use in manufacture and inspection.

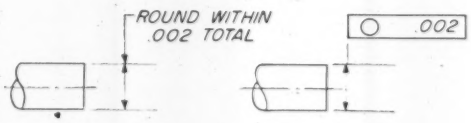
Flatness

Flatness specification can apply only to a single plane surface. It is independent of any dimensional location of the surface with respect to a datum. It is also independent of any dimension of part size; that is, any reference to maximum or minimum material condition, or to feature size.



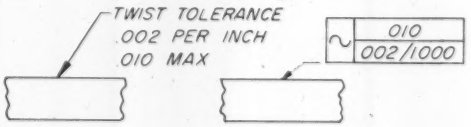
Roundness or Circularity

Roundness is one of the most difficult geometric characteristics to define or to inspect. Knowing when or how to specify it is also a problem. It is, of course, independent of any reference to a datum and to feature size, so there is no need for crowding the tolerance specification. However, to avoid misinterpretation of the roundness symbol as a zero in front of the tolerance value, a vertical dividing line may be used in the tolerance frame.



Twist

Twist limits are usually covered by specifications for flatness, straightness, or parallelism. However, where requirements of these other characteristics are of minor importance, a separate specification of twist tolerance may be desirable. Twist is usually specified per unit of length, with an overall maximum which must not be exceeded regardless of length. Twist tolerance is, of course, without reference to a datum, and is independent of feature size.



Straightness

Straightness specification may be applied to the axis of a shape of revolution, to the median plane of a symmetrical shape, or to the surface of a cylindrical shape or a prismatic shape such as a square, rectangle, or polygon.

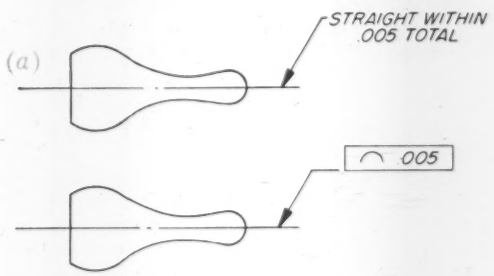
Since it is possible for a shape to have a straight axis but no straight elements, any straightness specification for such parts must be applied to the axis, *a*. Such a specification is, of course, independent of the size of the feature and, thus, the maximum material concept does not apply.

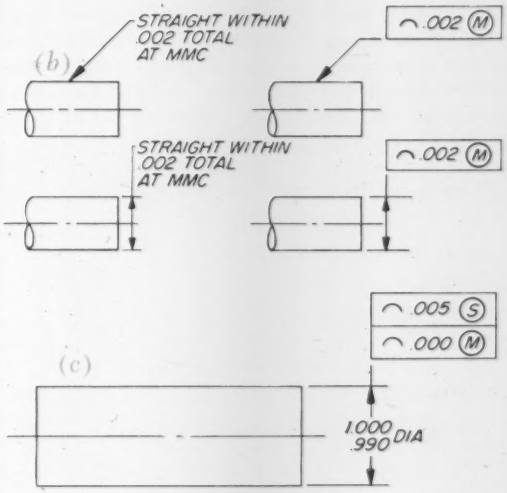
However, for cylinders where straightness of the surface elements is important, the straightness specification should be applied to the outside surface of the feature, *b*. Since straightness at the outside surface of a feature is dependent upon the actual finished size of the feature, the appropriate qualifying symbol must be included in the tolerance specification if applicable, *b*.

If, for functional reasons, the part requires a straightness tolerance under any conditions of size and, also, must not exceed the envelope of perfect form at the maximum material condition, this requirement may be specified with a double symbol, *c*.

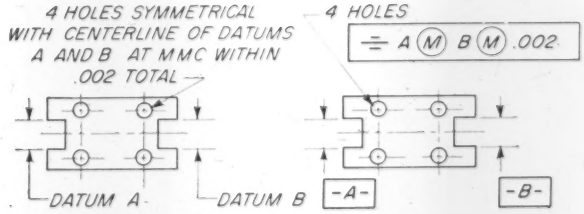
This specification states that the profile of perfect form must be maintained at the maximum material condition; effective size of the part can be no greater than this condition. It also provides a geometric tolerance to control the form as the actual finished size of the part departs from the maximum material condition. At *c*, the specific conditions are:

1. At the maximum material condition, straightness tolerance is zero.
2. For diameters less than the maximum material condition (1.000 in.), but greater than 0.995 in., the straightness tolerance is equal to the actual difference between the maximum material condition and the actual size.
3. For diameters less than 0.995 in. but greater than the minimum size limit (0.990 in.), straightness tolerance remains constant at 0.005 in.





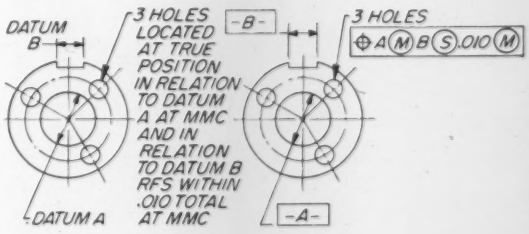
Symmetry



Symmetry tolerance is always specified with a datum reference. The datum may be the axis or median plane of a single feature, or the common axis or median plane of two features. Specification of a symmetry tolerance limits the amount of permissible displacement of a feature in a direction at right angles to the datum, without reference to the tolerance in the direction of the datum. In the specification of symmetry tolerance, the feature size must always be considered, and the appropriate qualifying symbol must be included in the tolerance symbol frame, when applicable. Unless otherwise specified, symmetry tolerances apply regardless of feature size.

True Position

In the true-position method of tolerancing feature location, the note form is especially lengthy, and the use of symbols shows decided savings. True-position specification is always in reference to a datum, which, unless perfectly obvious, must be indicated. Also, when the true-position notation is used, the qualification of size, for either "regardless of feature size" or maximum material condition, must be included in the specification.


DATUM B
3 HOLES LOCATED AT TRUE POSITION IN RELATION TO DATUM A AT MMC AND IN RELATION TO DATUM B RFS WITHIN .010 TOTAL AT MMC
-B-
3 HOLES
⌖ A Ⓜ B Ⓢ .010 Ⓜ
DATUM A
-A-

identifying temporary datum features for manufacture and inspection.

The datum reference letter should be placed between the symbol and tolerance value in the tolerance frame. It will then serve as a separator, eliminating the need for a vertical dividing line and making the specification read more naturally.

When a datum feature is a plane surface, size limits of the feature do not affect reference tolerance relationships and no qualification need be used with the datum reference.

However, when the datum is other than a plane surface (such as a hole, slot, or cylindrical shaft), the datum feature is expected to apply regardless of size unless the qualification of maximum material condition is specified. When measurement normally is made by rotating the part about the axis of the datum surface to check deviation of another feature with an indicator, or when the datum feature is located by a tapered plug or ring, the datum reference applies regardless of actual finished size of the datum feature. However, when measurements of feature deviation are related to a datum surface located by a pin or ring receiver gage, the qualification of maximum material condition should be included in the tolerance specification.

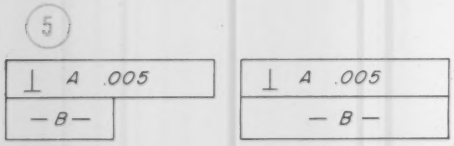


Fig. 5—Recommended form of notation for a part feature which serves as a reference datum for tolerancing of other features and, also, is controlled by a geometric tolerance.

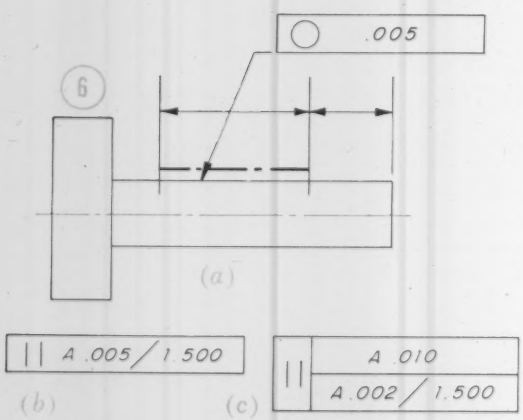


Fig. 6—Tolerance specifications for limited portions of part features. At *a*, tolerance applies only to length of part defined by heavy dashed line. Tolerance specification at *b* controls limited lengths lying anywhere on the part feature. Specification at *c* provides one tolerance for whole feature and another tolerance for limited lengths.

When a part feature serves as a reference datum for tolerancing of other features and also is controlled by a geometric tolerance, the feature tolerance specification and datum reference are combined by placing the datum symbol below the tolerance symbol, Fig. 5.

Unless otherwise specified, a geometric tolerance applies to the entire length or area of the feature concerned. However, if the tolerance applies only to some definite length or area on the feature, this area may be identified by a heavy long-and-short dash line, placed adjacent to the object line on the drawing and separately dimensioned, Fig. 6*a*.

Also, if the tolerance is to apply only to limited lengths lying anywhere on the feature, this specification is made in the note form by giving the tolerance per unit of length. With symbols, the limited length value is inserted in the tolerance symbol frame after the tolerance value and separated from it by an inclined bar, Fig. 6*b*. If the tolerance is applied to a limited area, the same notation is used.

In addition, one tolerance may be applied to the whole feature and another to a limited part of the feature by placing the latter tolerance value below the other value, Fig. 6c.

This specification, Fig. 6c, means that the feature is to be maintained parallel to datum *A* within 0.010 in. over its entire length and within 0.002 in. in any 1.500 in. length at any place or in any direction.

Qualifying Conditions: The symbol for maximum material condition, Table 1, is located in one of three positions: 1. After the tolerance value when the qualification applies to the toleranced feature, Fig. 7*a*. 2. After the datum reference letter when the qualification applies to the datum feature, Fig. 7*b*. 3. After both when the qualification applies to both, Fig. 7c.

If a general note on the drawing states that the qualification of maximum material condition is to be applied throughout, tolerances not subject to that general specification may be identified by adding the symbol for "regardless of feature size" in the tolerance specification, Fig. 7*d*.

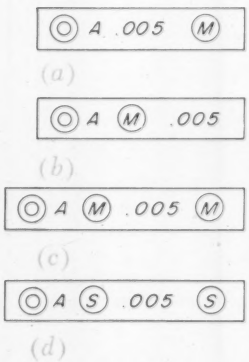
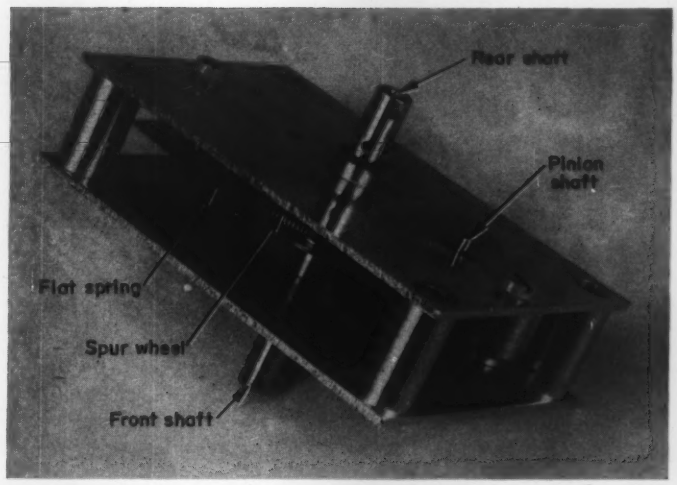
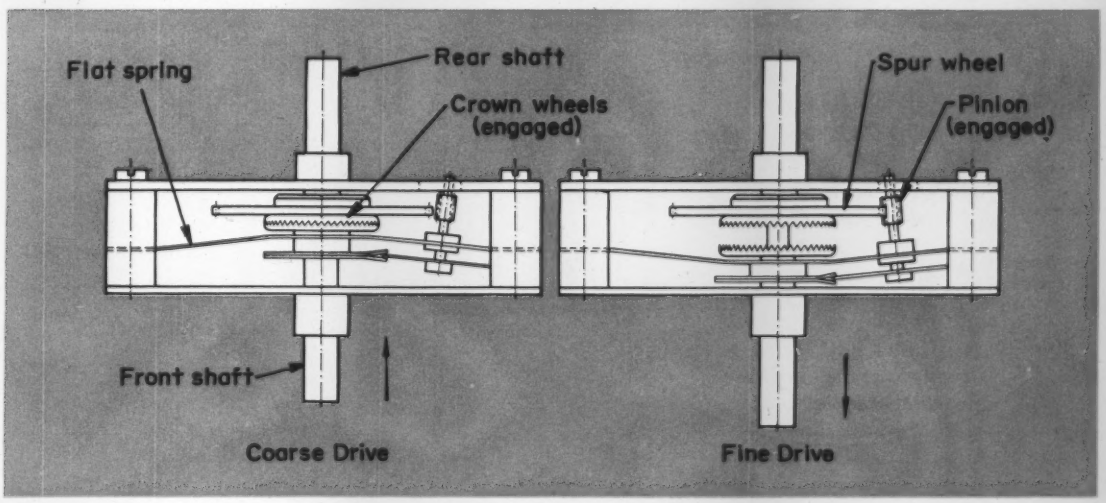


Fig. 7—Methods of specifying qualifying conditions. Maximum material condition applies to toleranced feature at *a*, to datum reference at *b*, and to both features at *c*. Specification at *d* may be used to identify tolerances not subject to a general requirement of maximum material condition.

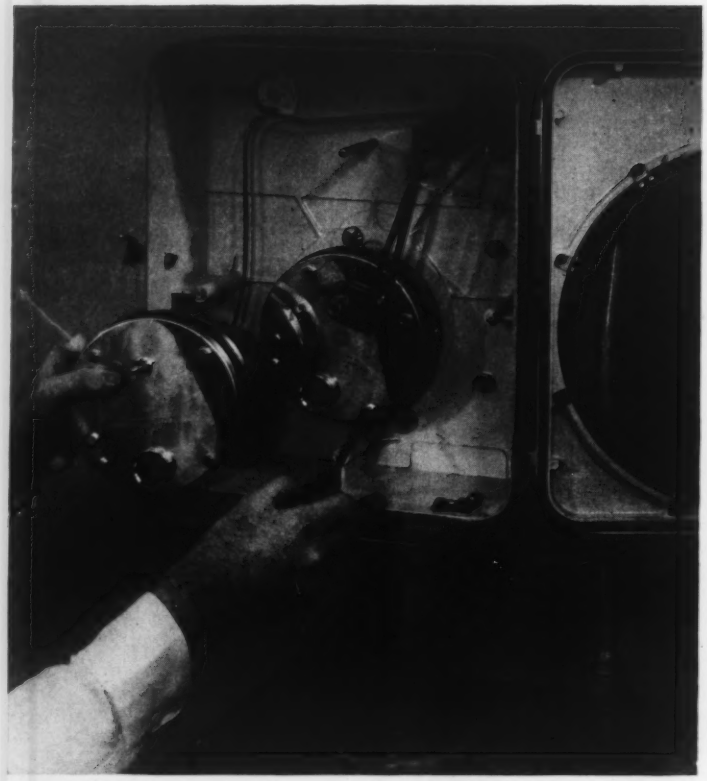
scanning the field for *ideas*

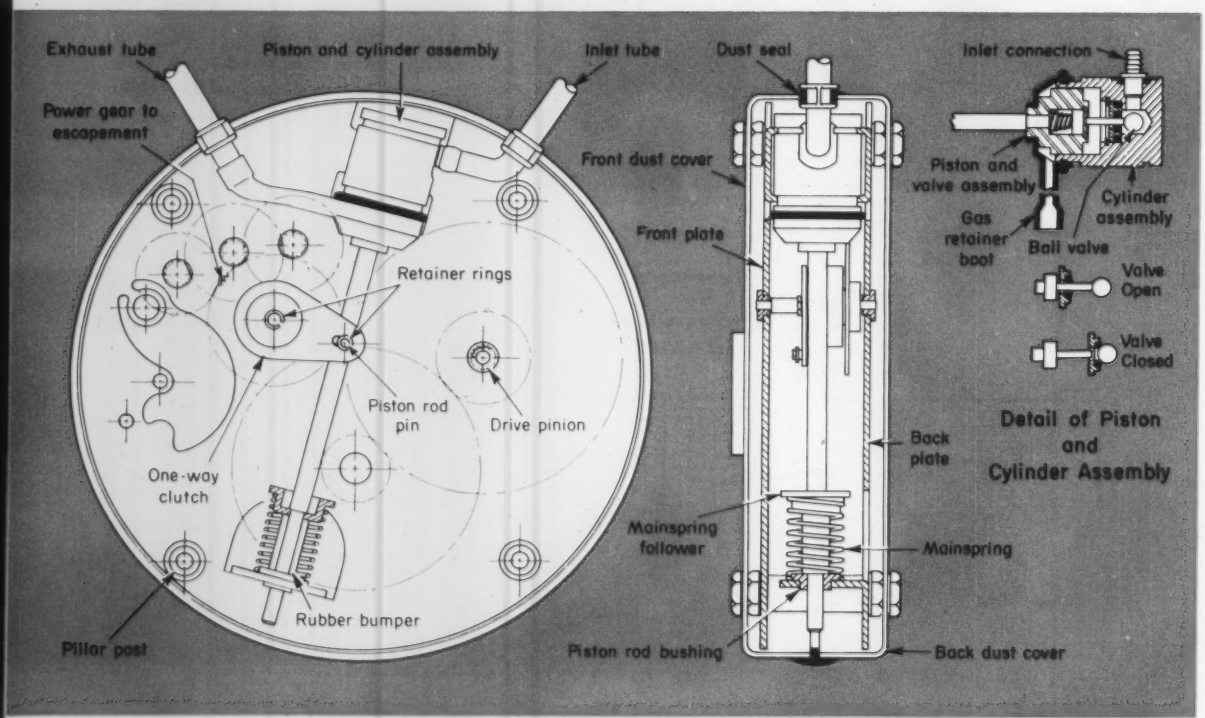
Flat tension spring shifts single-knob coarse - and - fine drive mechanism into either position. For coarse adjustment, spring disengages spur wheel and pinion of fine drive, engaging two crown wheels for direct connection of front and rear shafts. For fine adjustment, withdrawal of front shaft shifts spring into other end position, disengaging crown wheels and engaging pinion with spur wheel mounted on rear shaft. The front shaft is connected to the floating pinion by a continuously engaged friction drive consisting of three interlocked metal discs. One disc on the pinion shaft nests between two discs on the front shaft. Spring action avoids intermediate positions by maintaining front-axle half in either end position. Tension-spring design employed in a tuning mechanism developed by Telefunken GmbH, Berlin, Germany.



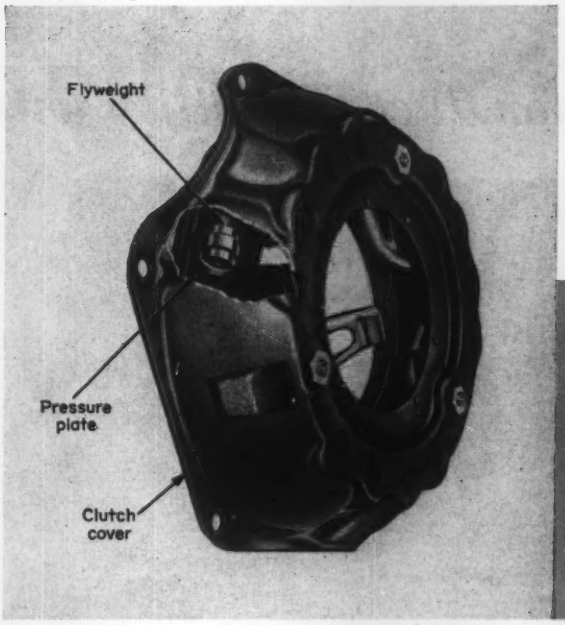


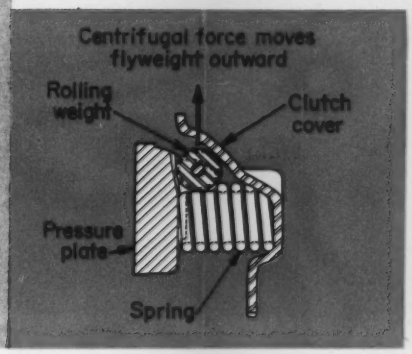
Gas-powered timer drive uses compression "mainspring" as power reservoir. The drive assembly consists of a piston and cylinder assembly which transmits force to a helical compression spring through an extended piston-rod. A connecting rod attached to the piston rod at an intermediate point is linked with the gear train of the timing mechanism by a one-way clutch. Gas under pressure is admitted to the piston through a ball valve, moving the piston rod to compress the spring. At the end of the piston stroke, a valve shuts off the gas pressure to the piston, permitting the spring to apply pressure in the opposite direction as it extends itself. The clutch is now engaged and drives the gear train until the piston moves to a position where the valve opens and gas pressure is once again admitted to the piston. One charging cycle occurs every 35 seconds. Timing principle employed in a gas drive developed by Rockwell Mfg. Co., Pittsburgh, Pa.





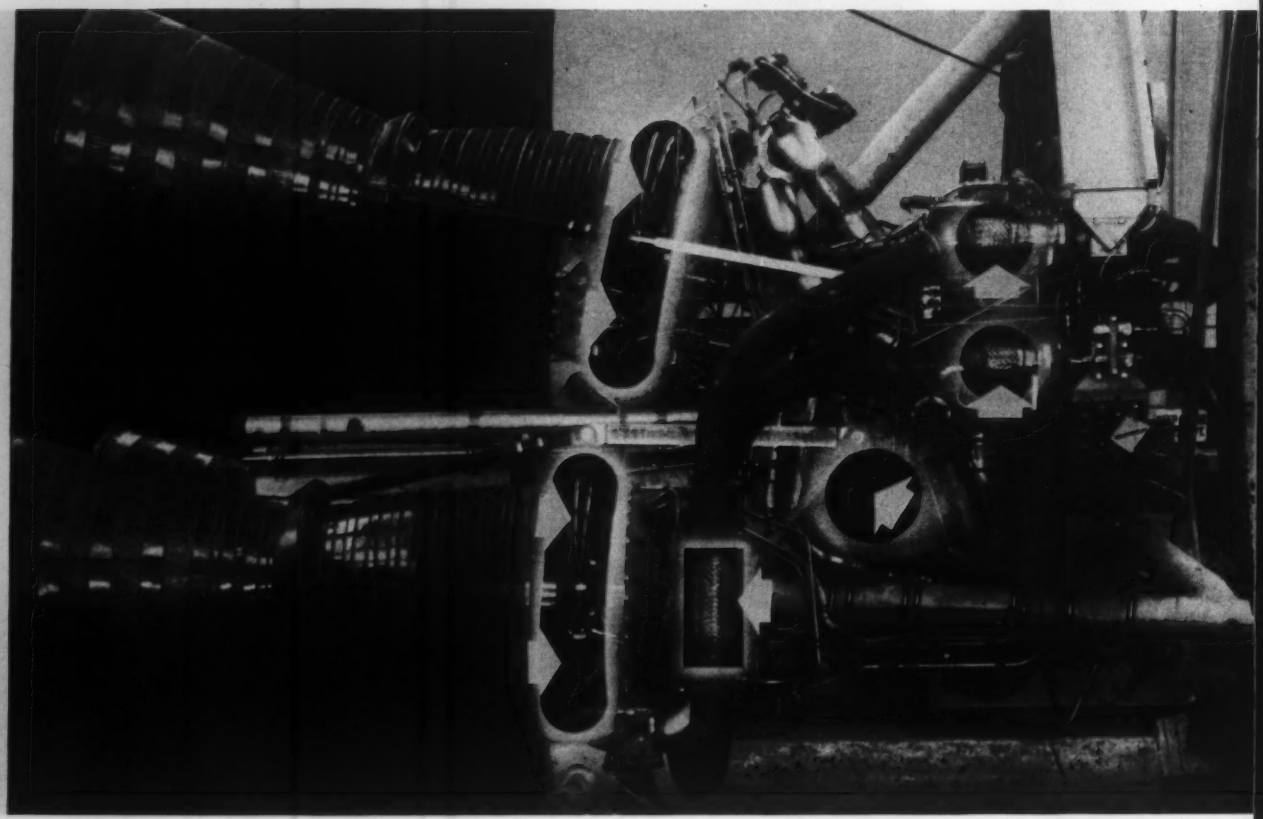
Rolling flyweights assist spring action in semicentrifugal clutch. In a manually operated clutch, light pressure springs permit the pressure plate to be easily disengaged. To maintain high engagement force, six cylindrical flyweights are used. As engine speed increases, the rolling weights move outward under centrifugal force to wedge between the pressure plate and the sloping clutch cover. Force developed at the pressure plate by the wedging action acts to increase the torque transmitting capacity of the clutch at high speeds. Clutch principle employed in the 1960 Dodge V-8.





Wound-wire sleeve construction permits fluid to flow through walls at controlled rate. Sleeves are made by winding wire onto a mandrel. The winding pattern determines the pore size. Wall thickness and density are controlled by varying the number of wire layers. After winding, the tubular forms are sintered to bond the wires together at each contact point. Wire size, wire spacing, sleeve diameters, and sleeve lengths are varied to regulate the flow rate. Wound-wire construction technique developed by Bendix Filter Div., Bendix Aviation Corp., Madison Heights, Mich.

Designing for duct flexibility with



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Interconnect Components Group
Rocketdyne
Div. of North American Aviation Inc.
Canoga Park, Calif.

bellows joints

In ducting systems, bellows offer flexibility to absorb thermal expansion and contraction, installation misalignment, structure deflection, and vibration.

This article presents a complete roundup of the factors that influence their selection and application. It is based upon the design of aircraft and missile fuel systems where ducts run the gamut of extreme temperatures, pressure, and flow velocity.

Joint Movements

Axial Traverse: Elongation or contraction of the flexible joint from its neutral position along the longitudinal axis of the duct. During movement, faces of bellows remain perpendicular to the neutral center line.

Lateral Offset or Shear: Lateral displacement, perpendicular to longitudinal axis, of one end of the joint relative to the other end. Both ends remain parallel and perpendicular to the neutral center line.

Angular Rotation or Angulation: Rotation of one or both ends of the joint with respect to each other. Either one or both faces are not perpendicular to the undeflected neutral axis position.

Combined Motions: Combination of any or all of the previously mentioned motions occurring simultaneously in a joint. Preferably, to prevent overstressing, joint should be required to take only one type of motion.

BELLOWS are corrugated cylinders which have a wall thickness that is relatively thin compared to the wall thickness of the duct in which it is used. Bellows possess a high degree of axial and angular freedom of motion because of the flexible radial sides of the corrugations, called discs.

Selecting the type of configuration and the material for a specific bellows affects the performance of the joint. This performance does not always meet the anticipated level. Hence, performance testing and quality control must also be considered during design.

▶ Load Characteristics

Since bellows have unique properties, their capabilities and limitations should be carefully analyzed for each duct application.

Expansion: Axial expansion is governed by the

thrust developed in the bellows by internal pressure. The area of a bellows used in computing end thrust is that area which has as its diameter a circle approximately midway between the ID and OD of the bellows.

For expansion joints with practically any corrugation shape, the area upon which the applied pressure acts has a diameter approximately equal to that of the mean diameter of the corrugation. This area differs for each size joint and depth of corrugation and is called the effective area of a joint. The product of the effective area and the internal pressure produces a force or thrust on the adjoining structure which contains the joint.

RESTRAINT: Many types of restraint are used to prevent axial expansion caused by the internal pressure thrust. The type of restraint used for a particular duct application depends on many factors: Type of motion to be accommodated, allowable bending moment, available space, allowable weight, cost, and pressure loss. Optimum duct design may require bellows with various restraints, each selected to do a particular job.

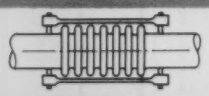
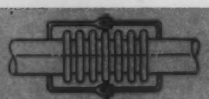
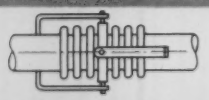
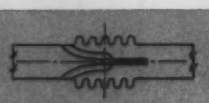
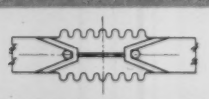
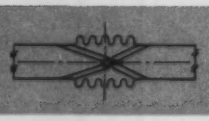
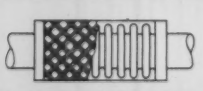
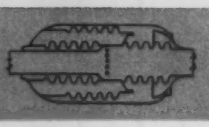
Characteristics for some typical restraint designs are given in Table 1. The omega joint, equalizing ring, and offset joint depend upon the adjoining structure for their restraint.

Buckling: As a general rule, the live length of a relatively flexible, unsupported bellows should be less than the diameter of the ducting to prevent buckling during operation. With a stiffer bellows, the live length can be longer than the diameter if the increased spring rate does not adversely affect the system performance. Also, longer lengths are practical when an external or internal guide or braid is used. The internal pressure at which a bellows becomes unstable and buckles is the critical buckling pressure.[1]

EQUALIZING RINGS: Cast or fabricated external equalizing rings can be used in expansion joints to support the roots of the convolutions, Table 1. In most commercial applications, these rings limit the amount of compression imposed on any one convolution. This limiting is accomplished by hav-

[1]References are tabulated at end of article.

Table 1—Flexible

	Flexibility	Load to Deflect	Weight	Pressure Drop	Cost	Envelope Size
	**Double Hinge** Single plane angulation, lateral offset	Low	Medium	That of bellows only	Medium	Large in one plane
	**Single Hinge** Single plane angulation	Low	Medium	That of bellows only	Medium	Large in one plane
	**External Gimbal** Angulation in any plane	Low	Heavy	That of bellows only	Expensive	Large
	**Internal Hinge** Angulation in any plane	Low	Less than external hinge	1/3 velocity head or more	Least expensive gimballed type	Small (nothing external of bellows)
	**Internal Cable** Angulation in any plane, lateral offset	Low	Less than external hinge	1/3 velocity head or more	Inexpensive gimballed type	Small (nothing external of bellows)
	**Internal Ball and Socket** Angulation in any plane	Low	Less than external hinges	1/3 velocity head or more	Inexpensive gimballed type	Small (nothing external of bellows)
	**Braided Wire Restraint** Angulation in any plane	High	Medium	That of bellows only	Low	Small (not much larger than bellows)
	**Pressure Balanced or Compensated** Axial, angulation in any plane, lateral offset	Bellows spring rate	Heavy	Two lengths of bellows	Expensive	Very cumbersome

ing the tops of the rings progressively come into contact with one another. Hence, the thermal movement is transmitted from one convolution to the next adjacent convolution, until the joint is fully compressed.

When weight is a critical factor, the rings can be used to increase the amount of hoop stress the joint can sustain. This permits the use of a thinner bellows wall and a lower spring rate. In addition, the external rings also prevent lateral buckling of the bellows by providing support at the inner edge.[2]

Deflection: The ability of a joint to deflect axially is predictated by the flexibility of the bellows. Flexibility is dependent upon the modulus of elasticity of the material and diameter of the bellows, and the size, shape, thickness, and number of convolutions. Flexibility is directly proportional to the number of convolutions per given length if the size of convolutions and wall thickness are constant. For example, if a bellows has a two-ply wall with a combined thickness equal to a single-ply bellows wall, the two-ply bellows will provide almost twice the flexibility of the single-ply bellows. Within its elastic limit, the action of a convoluted bellows is closely related to that of a helical spring, and deflection is proportional to the applied load.

Fatigue: The most frequent cause of bellows failure is fatigue. A bellows can be considered analogous to a spring mass. Critical frequencies are a function of the mass and the bellows spring rate. A higher spring rate or a lower mass results in higher resonant frequencies. These resonant frequencies of vibration in bellows are induced either by mechanical means, high noise levels (130 db and above), or by high velocity fluids impinging on the internal surfaces. In particular, high-velocity compressible fluids impose vibrations which can cause early failure if not taken into consideration. This problem can usually be solved by lining the inside of the bellows to prevent impingement of the flow on the convolutions.

Overstressing of bellows prior to installation can impair the life of the bellows. Hence, even though the stress experienced may be quite low, it should

Bellows Joint Characteristics

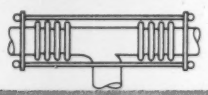
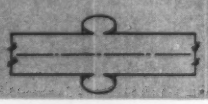
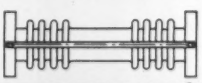
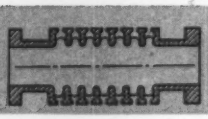
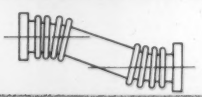
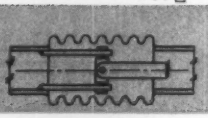
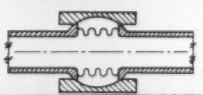
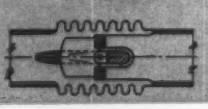
	Flexibility	Load to Deflect	Weight	Pressure Drop	Cost	Envelope Size
	**Pressure Balanced** Axial, angulation in any plane, lateral offset	Bellows spring rate	Medium	That of bellows only	Relatively low	Large and very long
	**Torus or Omega** Axial, angulation in any plane	Very stiff	Low	Low	Relatively low	Larger than plain bellows
	**Swing Joint** Lateral offset, angulation in one plane	Bellows spring rate plus bearing friction	Low	Two lengths of bellows	Relatively low	Large and very long
	**Equalizing Ring Joint** Lateral offset, axial, angulation in any plane	Bellows spring rate	Heavy	That of bellows only	Expensive	Small (not much larger than bellows alone)
	**Offset Joint** Lateral offset, axial, angulation in any plane	Bellows spring rate	Low	Two lengths of bellows	Low	Long
	**Internal Gimbal** Angulation in any plane	Low	Heavy	Depends on structure in flow stream	Expensive	Small
	**Ball-Bellows Joint** Angulation in any plane	High	Heavy	That of bellows only	Expensive	Large
	**Plane Hinge Gimbal** Angulation in any plane	Low	Low	1/3 velocity head or more	Expensive	Small (nothing external of bellows)

Table 2—Properties

Property	Stainless Type 321 Annealed	Stainless Type 347 Annealed	A-286	AM350 Heat Treated
Density (lb/in.³)	0.29	0.29	0.288	0.28
Linear Coefficient of Expansion (in./in./deg F)	7.5×10^{-6} (−320 to 68F) 9.3×10^{-6} (32 to 212F) 9.5×10^{-6} (32 to 600F)	7.5×10^{-6} (−320 to 68F) 9.3×10^{-6} (32 to 212F) 9.5×10^{-6} (32 to 600F) 10.6×10^{-6} (32 to 1200F)	8.3×10^{-6} (−320 to 70F) 9.37×10^{-6} (70 to 212F) 9.67×10^{-6} (70 to 1200F)	6.6×10^{-6} (68 to 212F) 6.9×10^{-6} (68 to 572F)
Yield Strength (psi)				
70 F	35,000	40,000	89,300	170,000 52,000 (Annealed)
−320 F	42,000	54,000	135,000	217,000
1200 F	22,000	22,000	62,500	140,000 (700F)
Ultimate Strength (psi)				
70 F	90,000	95,000	105,100	203,000 156,000 (Annealed)
−320 F	200,000	195,000	200,000	248,000
1200 F	50,000	50,000	103,500	210,000 (700F)
Modulus of Elasticity (psi)	28×10^6	27.6×10^6 (−320F) 25×10^6 (70F) 22.5×10^6 (1000F)	29.1×10^6	30.4×10^6 (80F) 25.4×10^6 (600F)
Remarks	Good for high and low temperatures. Low cost and available.	Good for high and low temperatures. Low cost and available.	Mechanical properties dependent on heat treatment.	Brittle at low temperature.

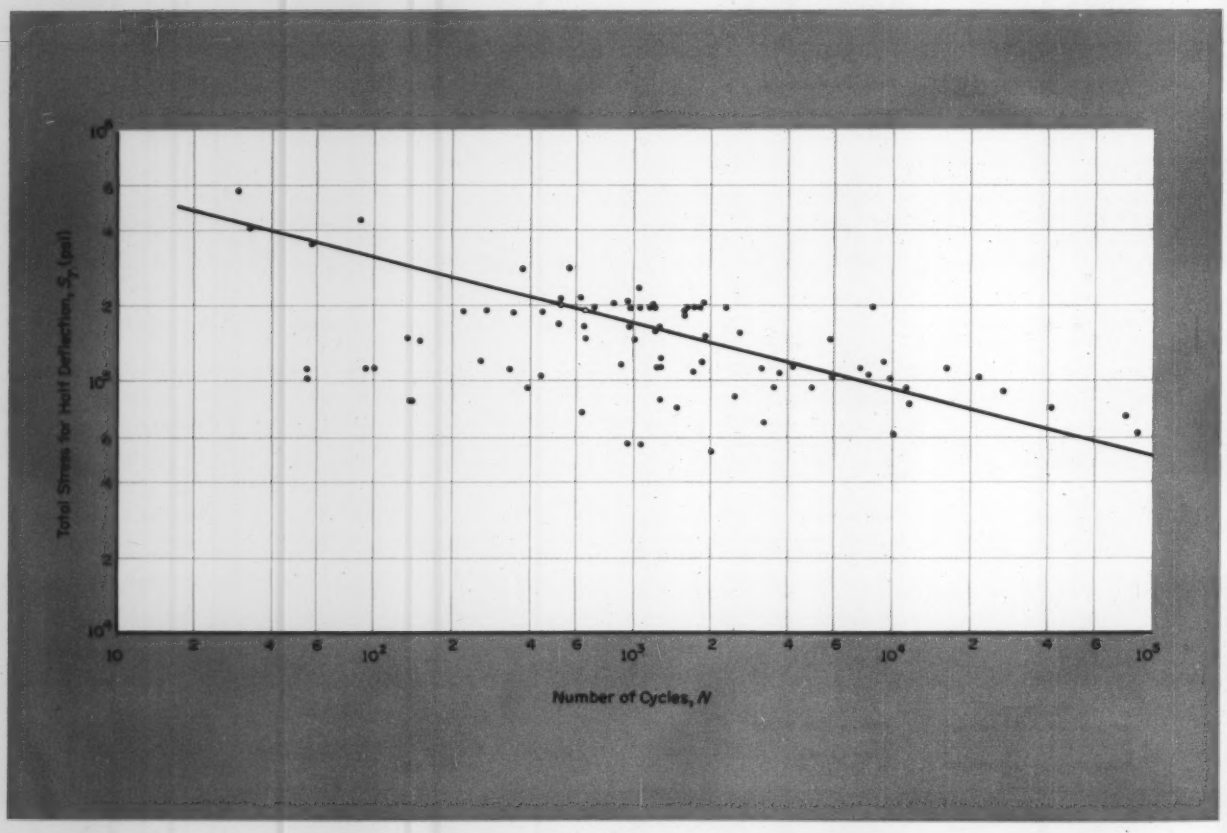


Fig. 1—Fatigue data indicate that life of bellows joint is directly proportional to total stress regardless of the configuration. Configurations tested included flexible hose, U-shaped, flat disc, and toroidal types.

of Bellows Materials

Inconel X Annealed Age Hardened	17-7 PH Condition TH 1050	Titanium	Aluminum 6061T-6	Property
0.30	0.276	0.16	0.098	Density (lb/in.^{3})
5.7×10^{-6} (−320 to 70F) 7.6×10^{-6} (100F) 8.4×10^{-6} (1200F)	5.6×10^{-6} (70 to 200F) 6.3×10^{-6} (70 to 600F)	3.85×10^{-6} (−320 to 70F) 5.7×10^{-6} (68 to 1000F)	10×10^{-6} (−320 to 68F) 13×10^{-6} (68 to 212F) 14.1×10^{-6} (68 to 572F)	Linear Coefficient of Expansion (in./in./deg F)
				Yield Strength (psi)
92,000	181,000 40,000 (Cond. A)	120,000	40,000	70 F
119,000	216,000		47,000	−320 F
82,000	160,000	63,000 (1000F)	7,000 (500F)	1200 F
				Ultimate Strength (psi)
162,000	196,000 130,000 (Cond. A)	130,000	45,000	70 F
192,000	237,000	235,000	60,000	−320 F
120,000	230,000	78,000 (1000F)	8,000 (500F)	1200 F
31×10^6 (80F) 23×10^6 (1200F)	29×10^6 (70F)	18.96×10^6 (−320F) 16.5×10^6 (75F) 10.1×10^6 (1000F)	10.2×10^6 (−320 to 68F) 9.8×10^6 (212F) 8.0×10^6 (500F)	Modulus of Elasticity (psi)
Good for high temperatures.	Brittle at low temperature.			Remarks

be taken into account. Pneumatic shock loading may result in metal fatigue, particularly in weld zones, and should be avoided whenever possible.

The speed at which a bellows is operated has little effect on life expectancy, except at very high frequencies. Where a destructive resonant frequency occurs, bellows life will be substantially curtailed.

Fig. 1 is a plot of fatigue data for flexible hose, U-shaped, flat disc, and toroidal bellows configurations of Type 321 and 347 stainless steel. Regardless of the configuration, all the data points fall generally along one line which obeys the expression $N = 1/S_T^n$, where N = number of cycles to failure, S_T = total stress due to deflection and pressure, and n = exponential constant. Although the total stresses, Fig. 1, are in excess of the annealed yield stresses of Type 321 and 347 materials, Table 1, hardness tests of cross-sectioned bellows show that Rockwell readings in the 25C to 40C range are found in the material due to cold working. The typical cross section analysis, Fig. 2, indicates that the bellows actually operate near the top of the elastic range or into the lower portion of the plastic range.

Various investigations have developed the following basic facts concerning bellows fatigue:

1. Everything else being equal, an increased live length in the bellows gives longer flexing life.
2. Fatigue life at −320 F is usually 70 to 100 per cent longer than the fatigue life at room temperature.
3. A bellows which is stress relieved after forming has a significantly shorter life than if the work hardened properties developed during forming are retained.
4. Fatigue cracks occur most often in the last or next to last convolution of braided hoses deflected angularly. However, in linkage-tied bellows which are deflected angularly, fatigue cracks occur most often in the center convolutions.

LINERS: Flow of gas or fluid passing through an expansion joint can be streamlined by liners. Turbulence and eddying in the corrugations and resultant friction losses are reduced. This streamlining effect also minimizes expansion joint failure caused by vibrations resulting from the turbulent flow. Furthermore, if the joint is not externally insulated, the liner creates an insulating dead space between the liner and the bellows. Hence, the temperature of the bellows will be lower than that of

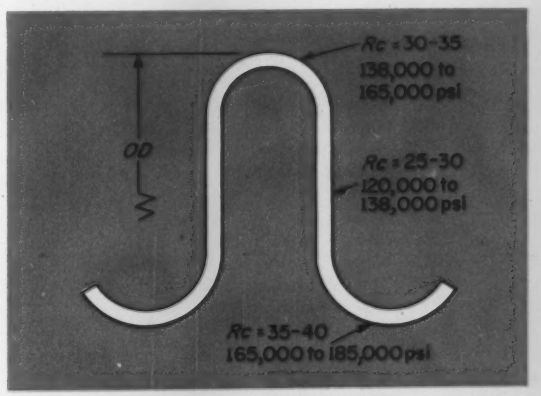


Fig. 2—Total bellows stress in excess of yield stress is induced by an increased hardness in material due to cold working. Typical hardness values are shown for roll-formed, Type 321, stainless-steel bellows.

Design Equations

Proper selection of bellows for flexible duct joints requires that certain preliminary calculations be made. Forces and moments acting on the bellows, stresses developed in the joint, and life expectancy of the bellows can be estimated with the following equations:

Force to Extend or Compress Bellows

For flat disc bellows:[4]

$$F = \pi E D \left(\frac{t}{w}\right)^3 \frac{\Delta}{N_d}$$

For U-shaped convolutions (limit use to $w/3 \leqq h \leqq w$):[5]

$$F = \frac{4EDt^3\Delta}{3h^{0.5}w^{2.5}N_d}$$

Moment to Rotate Hinge Joint[4]

$$M = E\left(\frac{Rt}{w}\right)^3 \frac{\pi}{N_d} \sin\theta$$

Range of Stress (Bending plus Pressure)

For flat disc bellows:[4]

$$S_T = \frac{3Et\Delta}{w^2N_d} + \frac{pw^2}{2t^2}$$

For U-shaped bellows:[5]

$$S_T = \frac{1.5Et\Delta}{h^{0.5}w^{1.5}N_d} + \frac{pw^2}{2t^2}$$

For U-shaped bellows with backup rings:[5]

$$S_T = \frac{1.5Et\Delta}{h^{0.5}w^{1.5}N_d} + \frac{pw}{t}$$

Fatigue Life

For stainless steel bellows:[5]

$$N = \left(\frac{1{,}600{,}000}{S_T}\right)^{3.5}$$

Nomenclature

- D = Mean bellows diameter, in.
- E = Modulus of elasticity, psi
- F = Force, lb
- h = Half-corrugation pitch, in.
- M = Moment, lb-in.
- N = Number of cycles to failure
- N_d = Number of discs
- P = Internal pressure, psi
- R = Mean disc radius
- S_T = Total stress range, psi
- t = Disc thickness, in.
- w = Disc width, in.
- Δ = Total movement range (extension and compression, plus equivalent axial movement), in.
- θ = Angular movement, deg.

either the liner or the flow media. The liner not only protects the bellows from high temperature, but also from pitting or erosion.

Where lateral movement or angular rotation is involved, clearances are required between the liner and the bellows. Hence, the clear inside diameter of the expansion joint is reduced accordingly. If this reduction in inside diameter is objectionable, an over-sized bellows may be used.

Torsion: Bellows are quite rigid in torsion, and ducting is usually designed so that torsion is not applied to any of the bellows in the system. Some investigation has been done to determine how much torsional deflection a bellows will withstand. Although results are not all-inclusive, tests indicate that the torsional moment required to deflect a longitudinally convoluted bellows is high. For example, a Type 321 stainless steel bellows of this configuration with 6½-in. ID, 7⅝-in. OD, 9-in. line length, and 48 convolutions has a torsional spring rate of 30,000 lb-in. per deg.

▶ Materials Selection

Since bellows are often required to endure pressures of 25 to 2000 psi and temperatures from −425 to +1600 F, the success of a design is largely dependent on the bellows material.

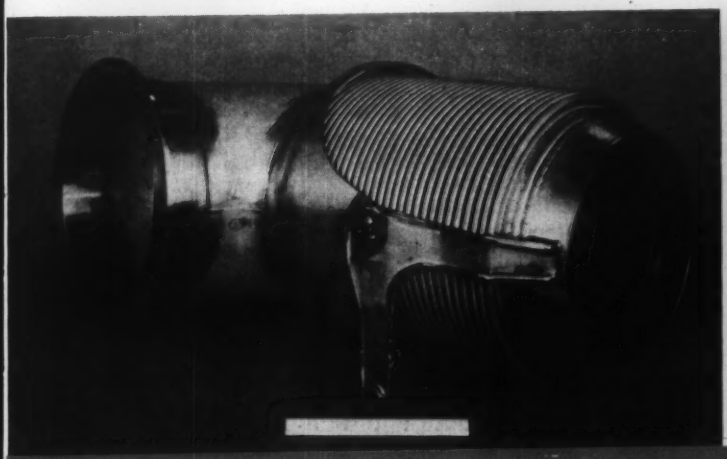
Strength: Basic properties for the more commonly used bellows materials are listed in Table 2. The tabulated values indicate that yield and ultimate strengths of all these materials increase with decreasing temperature. This characteristic is particularly important in liquid oxygen or other cryogenic applications. However, some materials, such as stainless steels 17-7PH and AM350, become brittle at low temperature and cannot be used. For Type 321 stainless steel bellows, fatigue life at −320 F (liquid nitrogen temperature) is considerably longer than at room temperature.

For elevated-temperature applications, all materials listed, except aluminum, retain their strength well up to 1200 F. For applications where temperatures up to 2000 F are experienced, more exotic materials must be used.

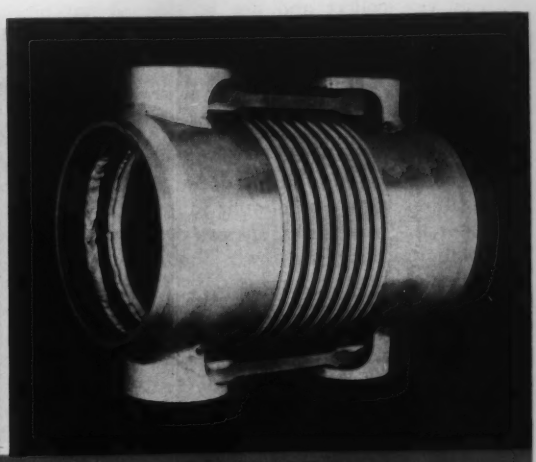
Compatibility: Material compatibility refers to the resistance of the material surface to the corrosiveness of the contained or flowing fluid. Some fluids, such as hydrogen peroxide, nitric acid, fluorine, hydrazine, and nitrogen tetroxide are highly reactive with many metals. Hence, finding a material or a surface treatment that will resist such activity is a real problem. No attempt will be made here to list all materials suitable for the various fluids. This discussion simply points out that the selection of a compatible material is sometimes the prime consideration in flexible-joint design.

Improper selection of materials can lead to cor-

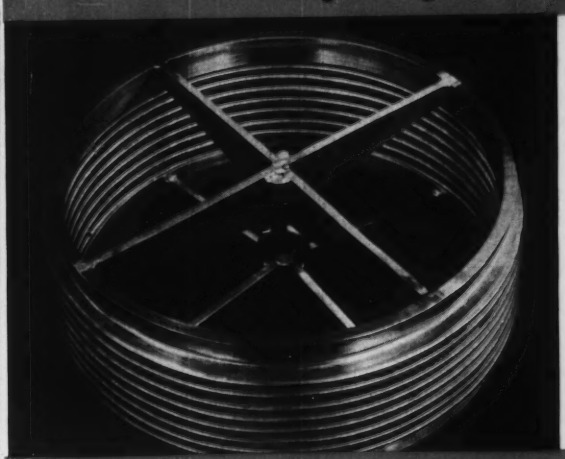
Common Bellows Joints



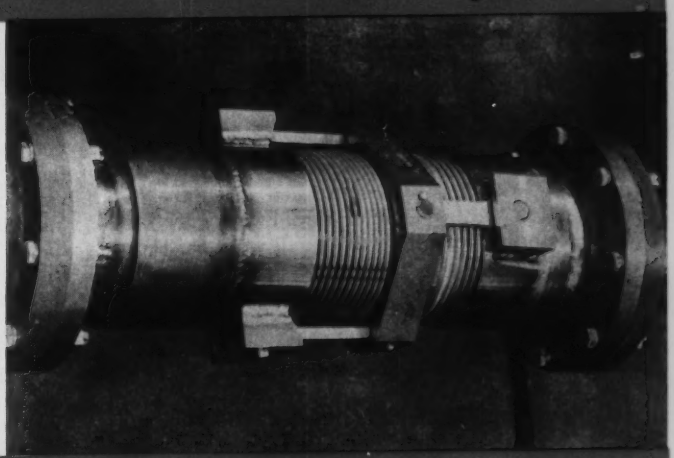
Single Hinge



Double Hinge

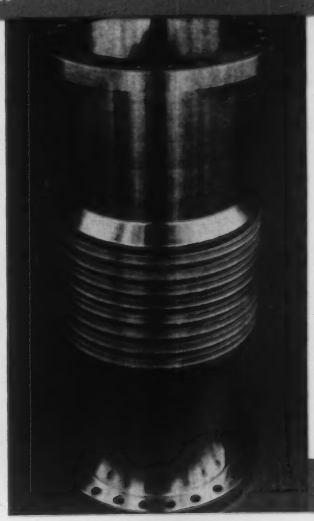


Internal Hinge



External Gimbal

Equalizing Ring



Offset

rosion of the bellows walls to the point where the structural integrity is impaired. Lap-weld crevices and other natural traps in which the corroding fluid can collect and not be cleaned out properly should be avoided. Bellows convolutions themselves are a fluid entrapment problem, and careful consideration should be given to the cleaning process.

Fabrication: Bellows are usually either hydraulically or roll formed. Hydraulic forming is usually preferable because it produces more uniform corrugations with a minimum thinning of the bellows material. In addition, stresses developed during hydraulic forming are lower than those induced by rolling or drawing processes.

Convolutions are formed simultaneously during hydraulic forming, and wall thinning of 10 per cent or less can be obtained. The entire process is a room temperature operation.

With roll forming, convolutions are formed one at a time and wall thinning of 10 per cent or less is difficult to attain.

Performance Testing

Because of the stringent requirements placed on rocket engine flexible joints in duct systems, and because bellows design is far from a science, the empirical design and development approach is a necessary one. It is a rare occasion when the first design of a flexible joint or flexible-joint duct system performs according to specifications. Laboratory and installation testing are, therefore, a very important and necessary aspect to flexible joint design. Performance testing usually falls into four general categories; spring rate or load, life cycle or fatigue, flow calibration, and vibration.

Spring Rate: The spring rate or load testing is performed on the joint alone, or on the whole assembly. Test specimens are mounted in a manner simulating actual installation conditions, pressurized to the normal operating pressure, and brought to the normal operating temperature. For low-temperature testing, liquid nitrogen is usually used to simulate the temperature condition.

The test specimen is deflected to simulate the motions expected in service and the loads required for deflection are measured. Axial, lateral offset, and angular spring rates are determined in this manner.

Fatigue: For fatigue testing, a test installation similar to that for spring rate tests is used. The deflections are imposed cyclically until failure and/or leakage occur. Pressure pulse cycling may also be imposed either along with the deflection cycling or alone.

Flow Calibration: Tests to determine the pressure loss characteristics of a joint or duct are another important type. Water is usually used as the flow medium for incompressible fluids, while air is used for compressible fluids. Correction factors applied to the results are used to convert data for the actual flow media. Standard ASME Test Code duct connectors and pressure taps are used.

For liquid flow, sufficient back-pressure must be kept on the test setup to prevent cavitation. A log delta-pressure versus log flow-rate curve should be plotted immediately after test to check the accuracy of the data. The curve obtained from this plot should have a slope of 2 or slightly less, since pressure loss is a function of velocity squared.

Flow calibrations for unsleeved bellows sections indicate that pressure losses for a given diameter duct can vary widely depending on the inside configuration. Such pressure losses are a function of the height of convolution to diameter ratio and the number of convolutions per unit length, within certain limits. Pressure loss in a bellows section can be fifteen times that of a straight plain tube or pipe with the same ID.[3]

If, in calculating the theoretical pressure loss for a typical close-coupled duct system, the loss factors given in hydraulics handbooks for connections and components are used, the error could be considerable. This is true because the loss factors for individual components are obtained from tests on that component alone. Hence, the flow disturbance that is set up affects the loss in the downstream duct connector and this loss is included in the loss factor. In a close-coupled system, however, the downstream disturbance is not allowed to occur, because another component follows almost immediately. The effect of one component on another in a circuit cannot be predicted accurately, and a flow calibration must be made to obtain the true loss.

Vibration: Another important test is the vibration test. Since it is often difficult to reasonably define the vibration environment of an installation, vibration tests are usually made after the duct system is installed. An element of risk is involved in this type of testing, since failure could cause damage to the complete installation. However, the first fatigue cracks which occur are usually small and can be detected and corrected before any damage is inflicted.

Vibration modes and attendant failures imposed on the bellows by internal flow can, of course, be detected during flow calibration, if the flow is continued for a sufficient period.

Quality Control

In the fabrication of flexible bellows joints within a company's shop or in purchasing from an outside shop to specifications, it is vitally important to have a rigid quality control and inspection test procedure to insure the acceptance of only functionally sound parts. The failure of a flexible joint in service may cause the failure of an entire system. A good quality verification procedure should include the following: 1. Dimensional examination.

2. Quality of workmanship examination. 3. Pressure tests. 4. Sampling tests.

Internal proof-pressure tests are usually conducted at about 1.5 times the normal operating pressure of the joint. This pressure may be higher depending on magnitude of surges anticipated in service. The tie linkage or braid are usually required to restrain the full pressure separating load.

Of the various sampling tests, the fatigue cycling test is most important. This test should duplicate the deflections, pressures, temperatures, and other environments through a number of cycles plus a safety margin which the joint is expected to endure in service. The number of joints which should be sampled depends on the consequences of joint failure in service, number of joints procured, relative cost of joints, previous service life, and previous sampling tests on the same or similar joints.

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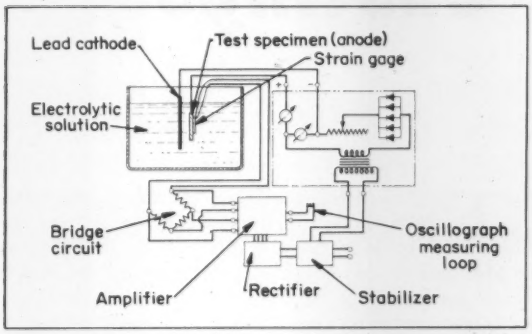
Tips and Techniques

Determining Residual Stresses

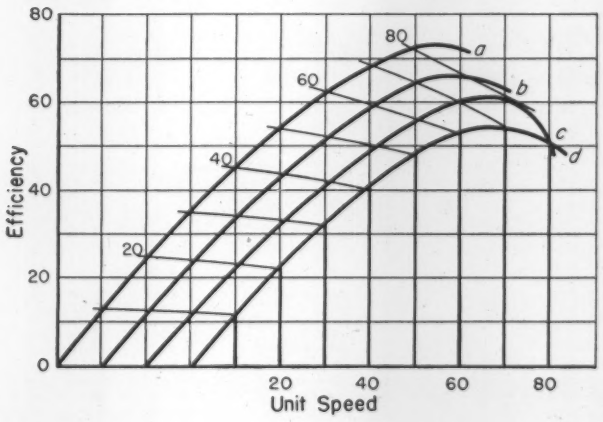


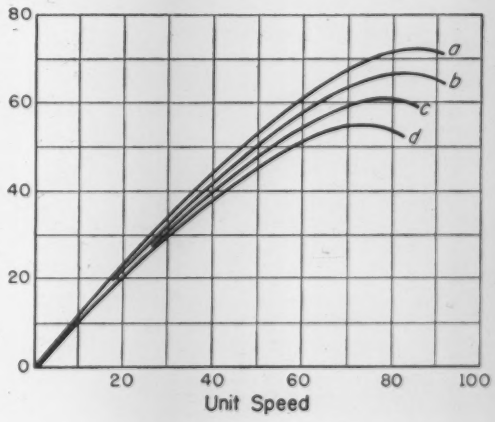
Electrochemical polishing process successively removes surface layers of test specimens for strain gage to measure deformation and determine residual stress resulting from previous cutting operations.

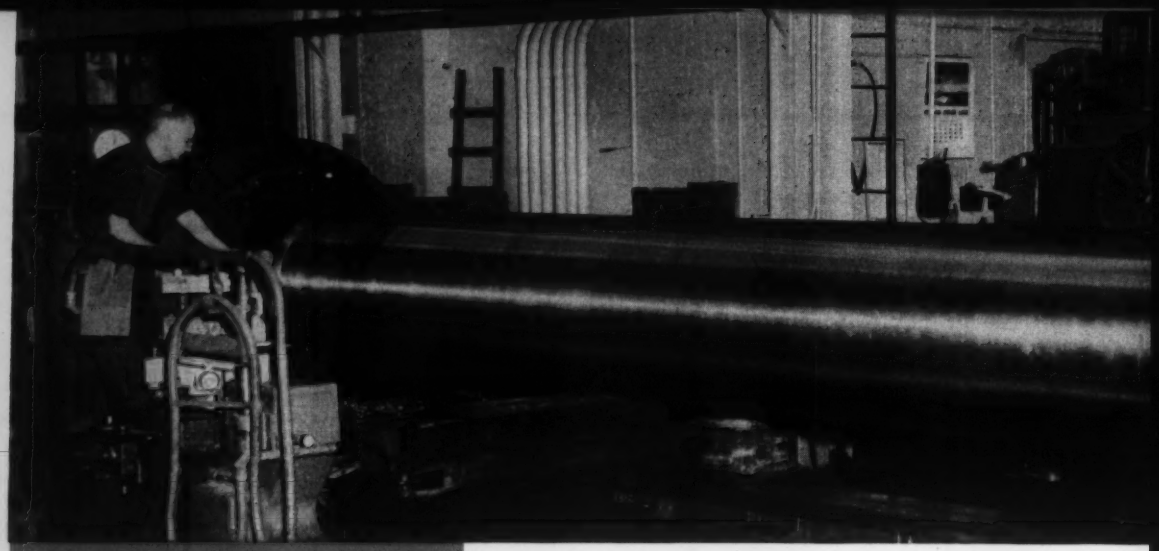
Strain gage is pasted onto accurately lapped side of specimen serving as anode. The cathode consists of a lead cylinder. Strain gage is part of a bridge circuit, the other three resistors of which are pasted onto the lapped surface of another part also submerged in the electrolytic solution to avoid errors resulting from temperature differences. The bath is held at a constant temperature of 86 F. Deformation of specimen is continuously recorded by a loop oscillograph.—Described in *Stanki i instrument* magazine, Moscow, USSR.

Carpet Graphs

Frequently the plot of a series of graphs is too crowded for easy interpolation. A typical example is the Pelton Wheel curves shown in the right figure. A carpet graph of the same data is shown in the left figure. To form the carpet graph, the curves are staggered from each other by some convenient unit. Lines joining corresponding points extend the horizontal scale.—W. H. SHEPPARD, *Renton, Wash.*







Applications and advantages of

Centrifugal Castings

Cast cylinders, conforming to Military, ASTM, and ASME-code specifications, are available in a wide range of alloys. They offer special advantages which suggest their use in many new and critical applications.

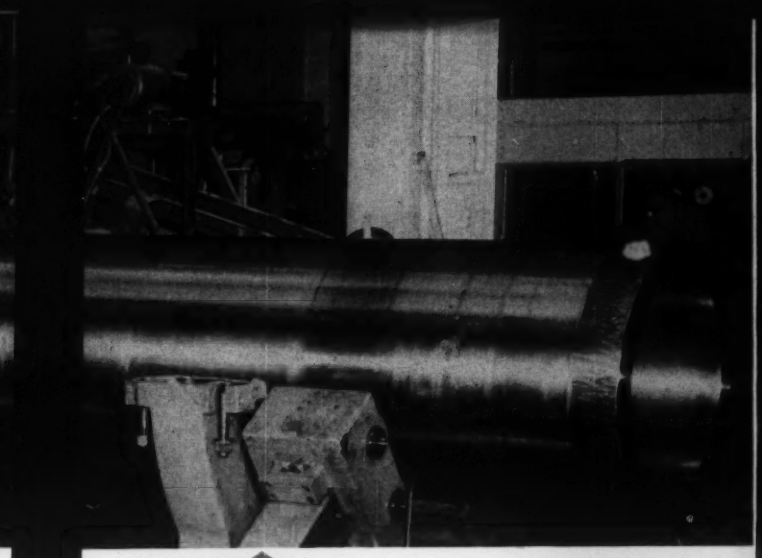
Data on which alloys to use and where to use them are based on information compiled by Sandusky Foundry & Machine Co.

THE centrifugal casting process yields single-piece, hollow cylinders ranging in size from 7 to 54 in. in diameter and up to 33 ft long. Mechanical and physical properties of the castings are uniform and nondirectional, and exceed minimum requirements of casting specifications, or wrought specifications for equivalent material. Because cylinders in the as-cast condition are dimen-

Table 1—Typical ASTM and Military Specifications for Alloys Used in ASME Code-Approved Centrifugal Castings*

Material	ASTM Spec.	ASTM Grade	ASME Spec.	ASME Grade	Nominal Composition	Tensile Strength* (1000 psi)	Yield Strength* (1000 psi)	Elongation in 2 in.* (per cent)
High-Alloy Steels	A 351	CF8†	SA351	CF8	18Cr-8Ni	70	28	35
	A 351	CF8M†	SA351	CF8M	18Cr-9Ni-2½Mo	70	30	30
	A 351	CF8C†	SA351	CF8C	18Cr-9Ni-Cb	70	30	30
Carbon Steels	A 216	WCA	SA216	WCA	.....	60	30	24
	A 216	WCB	SA216	WCB	.....	70	36	22
Low-Alloy Steels	A 217	WC6	SA217	WC6	1¼Cr-½Mo	70	40	20
	A 217	WC9	SA217	WC9	2¼Cr-1Mo	70	40	20
	A 217	C5	SA217	C5	5Cr-½Mo	90	60	18
	Military Specification		Class					
High-Alloy Steels	MIL-S-18262A (Ships)		1†		19Cr-9Ni	70	28	35
			2†		19Cr-10Ni-Cb	70	30	30
			3†		19Cr-10Ni-2½Mo	70	30	30
	MIL-S-867A (Ships)		1†		19Cr-9Ni	70	28	35
			2†		19Cr-10Ni-Cb	70	30	30
			3†		19Cr-10Ni-2½Mo	70	30	30

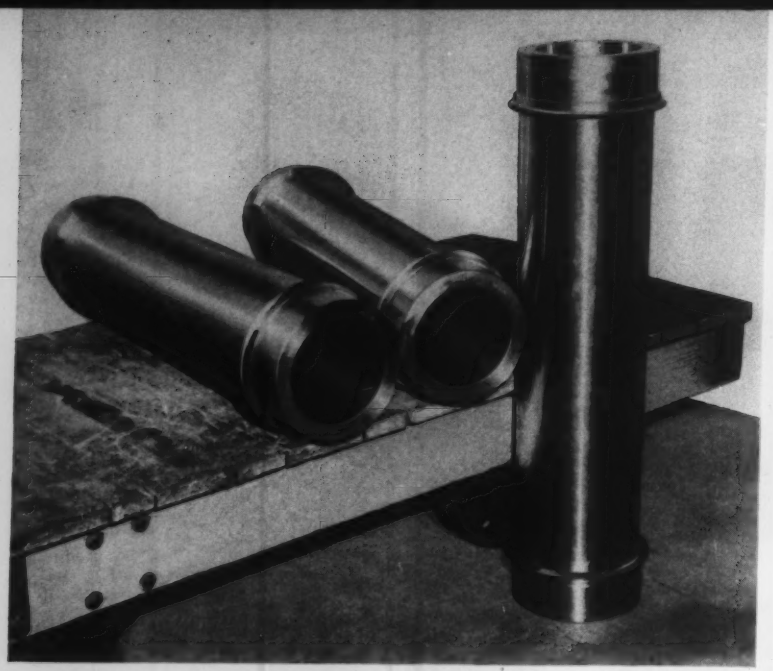
*Minimum ASTM and MIL spec. requirements. †Furnished for general application in ELC grades (0.03 per cent max) if required.



Machining a 25-ft, 17-ton casting centrifugally spun of a modified CF-8 (Type 304L) stainless steel. The casting measures 31¼ in. on the OD and has a 3-in. wall. It was cut into four 68-in. lengths for use as canned-motor pump bodies in an atomic-power system. Each pump handles 23,600 gpm of corrosive pressurized water through the reactor core.

A 10-ton carbon-steel cylinder used as an accumulator in a hydraulic roll-balancing system. This 18½-ft centrifugal casting has a 32-in. OD and 3½-in. wall. Essentially a pressure vessel, it simultaneously supports ram and ballast weighing 226 tons—the weight required to develop constant operating pressure of 1000 psi. Free from distortion, the one-piece cylinder eliminates binding and pressure loss during operation.

Equivalent Wrought AISI No.	Equivalent Casting Specifications	Equivalent Wrought Specifications
304, 317, 347	ASTM A 296; A 362	ASTM A 182; A 240; A 312; A 336; A 376
...	QQ-S-681b-1, MIL-S-15083-B	ASTM A 105-1; A 106-A; A 201-A; A 266-1
...	QQ-S-681b-2, MIL-S-15083-A 70	ASTM A 105-11; A 106-B; A 201-B; A 266-11
...	ASTM A 426-CP 11	ASTM A 182-F 11; A 335-P 11; A 336-F 2; A 387-C
...	ASTM A 426-CP 22	ASTM A 182-F 22; A 335-P 22; A 336-F 22; A 387-D
...	ASTM A 426-CP 5	ASTM A 182-F 5; A 335-P 5; A 336-F 5
304, 347, 316	ASTM A 296; A 351; A 362	.....
304, 347, 316	ASTM A 296; A 351; A 362	.....



Pressure vessels designed to operate at 3000 psi under Section 8 of ASME Code (Unfired Pressure Vessels). Castings are 34½ in. long, and have a 9-in. OD and 1½-in. walls.

Ammonia synthesis converter cartridges cast to ASTM A351 (modified to 0.03 per cent max carbon). Cylinders are 199 in. long and are finish machined to a 27¾-in. OD and 26⅜-in. ID. Flange is cast integral with the cylinder. The ID is held to 0.005 in. maximum out-of-roundness and 0.008 in. maximum taper in the full length to allow a precise fit of more than 7000 parts in each cylinder.

sionally close to specified sizes, only minimum machining is necessary to meet design requirements.

Many fabricating and forming operations required to produce a cylinder by other methods are eliminated by centrifugal casting. Production time is shortened and, in some cases, savings up to 50 per cent or more can be realized. These cast cylinders are gaining wide acceptance for many applications formerly served only by forgings or rolled-plate weldments. Also, the process offers possibilities for making cylindrical parts that can't be made as well—or at all—by any other method.

The Casting Process: No patterns or cores are required for centrifugal castings. Molten metal, poured into a spinning mold, is distributed in the shape of a hollow cylinder by centrifugal force. Rapid directional solidification progresses from the outer to the inner surface of the casting against high radial pressures. This assures full feeding of solidification shrinkage and improves the soundness and density of the casting.

Nonmetallic and other low-density materials, and gases liberated in cooling, are forced to the inner surface of the casting. This surface, the last zone to solidify, is always porous to a precalculable depth and is removed in boring the cylinder to the specified diameter.

Table 2—Heat, Corrosion, and Abrasion-Resistant Centrifugal-Casting Alloys*

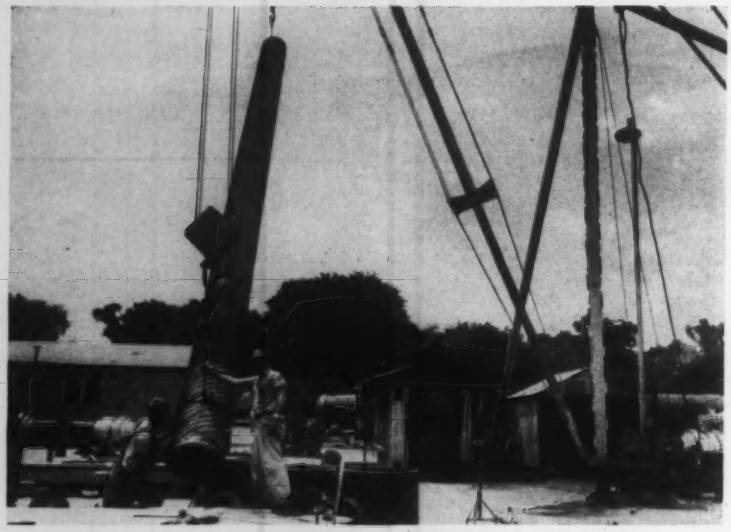
Material	ASTM Spec.	ASTM Grade	Tensile Strength (1000 psi)	Yield Strength (1000 psi)	Elongation in 2 in. (per cent)	Equivalent Wrought AISI No.	Equivalent Casting Specifications
Heat-Resistant Alloys	A 297	HC	55	..	..	446	.....
	A 297	HE	85	40	9	...	.....
	A 297	HF	70	35	25	302B	.....
	A 297	HH	75	35	15	309	ASTM B 190-50 Type 1, Type 2
	A 297	HI	75	35	15	...	.....
	A 297	HK	75	35	15	310	.....
	A 297	HT	65	..	4	330	ASTM B 207-50
	A 297	HU	65	..	4	...	.....
	A 297	HW	60	..	..	...	.....
	A 297	HX	60	..	..	...	.....
Corrosion-Resistant Alloys	.....	CF-3	65	28	35	304L-308L	.....
	A 296	CF-8†	70	28	35	304-308	ASTM A 351-52 T; A 362-52 T; MIL-S-867 (Ships), Class 1; MIL-S-18262 (Ships), Class 1
	A 296	CG-12	70	28	35	...	ASTM A 362-52 T
	A 296	CF-20	70	30	30	302	ASTM A 362-52 T
	.....	CF-3M	70	30	30	...	.....
	A 296	CF-8M†	70	30	30	316	ASTM A 351-52 T; A 362-52 T; MIL-S-867 (Ships), Class 3; MIL-S-18262 (Ships), Class 3
	.....	CF-3C	62.5	26	35	...	.....
	A 296	CF-8C†	70	30	30	347	ASTM A 351-52 T; A 362-52 T; AMS-5363-A; MIL-S-867 (Ships), Class 2; MIL-S-18262 (Ships), Class 2
	A 296	CF-16F	70	30	25	303	ASTM A 362-52 T
	A 296	CH-20†	70	30	30	309	ASTM A 351-52 T; A 362-52 T
	A 296	CK-20†	65	28	30	310	ASTM A 351-52 T; A 362-52T; AMS-5365-A
	A 296	CE-30	80	40	10	312	ASTM A 362-52 T
	A 296	CA-15†	90	65	18	410	ASTM A 351-52 T; A 362-52 T; AMS-5351-B
	A 296	CB-30	65	30	..	443	ASTM A 362-52 T
	A 296	CC-50	55	..	..	446	ASTM A 362-52 T
	A 351	CT-35†	65	28	15	...	.....
	A 351	CF-10-MC†	70	30	20	...	.....
Abrasion-Resistant Alloys	A 128	.....	..	..	..	...	MIL-S-17249 (Navy)

*Minimum ASTM requirements. †Suitable for high-temperature service.

Table 3—Properties of Plain Carbon and Low-Alloy Steels for Centrifugal Castings*

Material	ASTM Spec.	ASTM Grade	Tensile Strength (1000 psi)	Yield Point (1000 psi)	Elongation (per cent)	Area Reduction (per cent)	Corresponding AISI No.	Equivalent Casting Specifications
Carbon Steel (general application)	A 27	N1	..	..	..	..	1021	.....
	A 27	N2	..	..	..	..	1030	.....
	A 27	N3	..	..	..	..	....	.....
	A 27	U-60-30	60	30	22	30	1021	QQ-S-681b-1; 49S1-B, D
	A 27	60-30	60	30	24	35	1025	QQ-S-681b-1; 49S1-B, D
	A 27	65-30	65	30	20	30	1030	QQ-S-681b-2
	A 27	65-35	65	35	24	35	1026	QQ-S-681b-2
	A 27	70-36	70	36	22	30	1030	QQ-S-681b-2
	A 216	WCA†	60	30	24	35	....	QQ-S-681b-1 49S1-B, D
	A 216	WCB†	70	36	22	35	....	QQ-S-681b-2
	A 148	80-40	80	40	18	30	....	QQ-S-681b-4A1 46S33-A
	A 148	80-50	80	50	22	35	....	QQ-S-681b-4A1 46S33-A
High-Strength Steel (structural application)	A 148	90-60	90	60	20	40	....	QQ-S-681b-4A2, 4B1, 4B2, 4C1, 49S1-F
	A 148	105-85	105	85	17	35	....	QQ-S-681b-4C2
	A 148	120-95	120	95	14	30	....	QQ-S-681b-4C3
	A 148	150-125	150	125	9	22	....	QQ-S-681b-4C4
	A 148	175-145	175	145	6	12	....	.....
Alloy Steel (pressure and high-temperature application)	A 217	WC1†	65	35	24	35	....	QQ-S-681b-4A1; 46S33-A
	A 217	WC4†	70	40	20	35	....	QQ-S-681b-4A1; 46S33-A
	A 217	WC5†	70	40	20	35	....	.....
	A 217	WC6†	70	40	20	35	....	.....
	A 217	WC9†	70	40	20	35	....	.....
	A 217	C5†	90	60	18	35	....	.....
	A 217	C12†	90	60	18	35	....	.....

*Minimum ASTM requirements. †Suitable for fusion welding and high-temperature service.



Ammonia synthesis heat exchanger made of low-alloy steel to ASTM A217. Two centrifugally cast cylinders are welded together to form the 42-ft unit. Because operating conditions involve sharp temperature variations, the castings greatly minimize weld failure since only one circumferential weld is required in fabrication.

Table 4—Properties of Nonferrous Centrifugal-Casting Alloys*

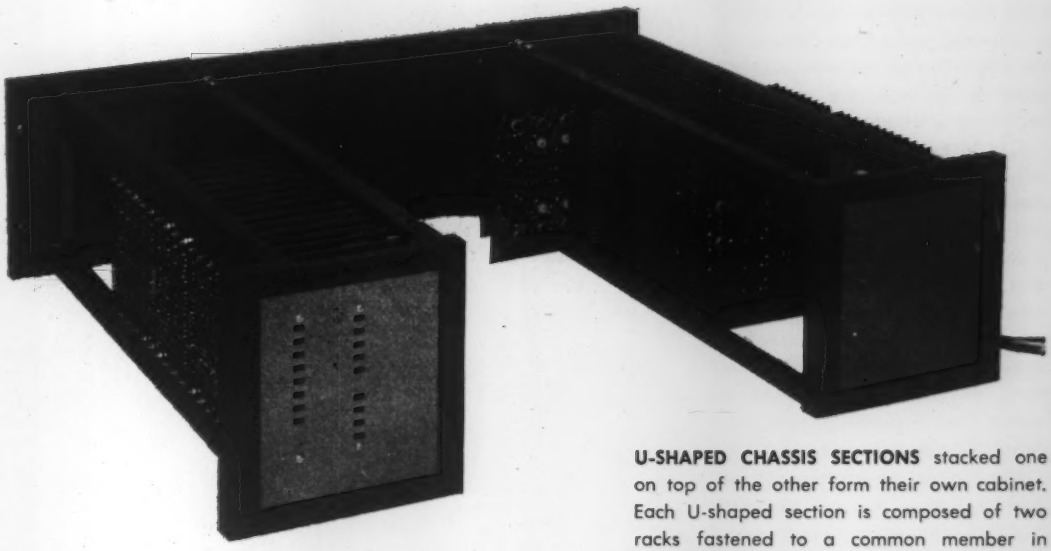
Material	ASTM Spec.	ASTM Grade	Tensile Strength (1000 psi)	Yield Strength (1000 psi)	Elongation in 2 in. (per cent)	Approximate Brinell Hardness	Equivalent Casting Specifications
88-10-2Zn	B 143	1A	40	18	20	65	.....
Gov't. G†	B 143	1B	40	18	20	65	MIL-M-16576; QQ-B-691b Comp. 5; SAE 620
88-10-2Zn-Pb	.....	....	36	..	18	65	.....
Navy M†	B 143	2A	34	16	22	65	MIL-B-16541; QQ-B-691b Comp. 1; SAE 622
Commercial G†	B 143	2B	36	18	18	65	MIL-B-16540; QQ-B-691b Comp. 6 & 6X; SAE 621
88-7-2-3	.....	....	40	..	15	..	.....
88-7-7-3†	B 144	3B	30	14	12	60	MIL-B-16261-Class 6; QQ-B-691b Comp. 12; SAE 660
84-8-8†	.....	....	25	..	8	60	MIL-B-16261-Class 2; QQ-B-691b Comp. 8
85-5-5-5†	B 145	4A	30	14	20	60	MIL-B-16444; QQ-B-691b Comp. 2; SAE 40
Sandusky 1N (85 to 87 per cent Cu)	.....	....	30	..	20	60	.....
Yellow brass	B 146	6C	40	14	15	50	46-B-10h QQ-B-621a(A)
Mn bronze†	B 147	8A	65	25	20	125	MIL-B-16443; QQ-B-726c Grade A; SAE 43
Mn bronze†	B 147	8B	90	45	18	160	MIL-B-16522 Class 2; SAE 430
Mn bronze	B 147	8C	110	60	12	225	MIL-B-16522 Class 1; SAE 430
Al bronze	B 148	9A	65	25	20	110	MIL-B-16033 Class 1; QQ-B-671b Class 1 Type 2; SAE 68
Al bronze†	B 148	9D	90	40	6	190	MIL-B-16033 Class 4; QQ-B-671b Class 4 Type 2; SAE 68
Sandusky 55 (18 to 22 per cent Ni)	.....	....	75	55	10	160	.....
Regular Monel	.....	....	65	32.5	25	125	MIL-N-20164; QQ-C-551
H-Monel	.....	....	70	45	10	220	MIL-N-20165; AAF Spec. 11084 Grade 1

*Minimum ASTM requirements. †Compositions covered by ASTM B271-52 T and MIL-C-15545-C (Ships) which pertain specifically to centrifugal castings.

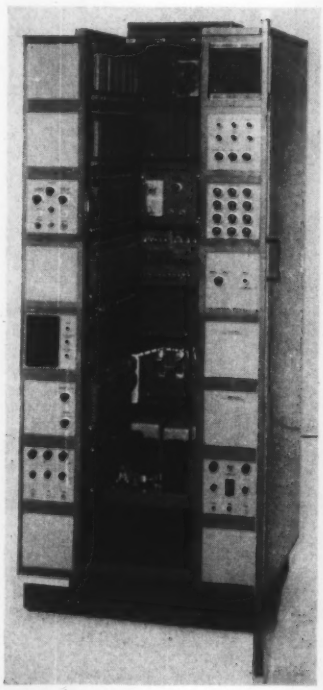
Materials: Centrifugally cast cylinders, conforming to all requirements of the ASME Boiler and Pressure Vessel Code, Section 8, Unfired Pressure Vessels, are currently being produced to the specifications shown in Table 1. In some instances, meeting standards for code approval is less complicated with centrifugal castings than with cylinders produced by other methods of fabrication.

Castings are available in high-alloy steels (in ELC grades for improved corrosion resistance), low-alloy steels, plain carbon steels, and in nickel-base and copper-base alloys. Composition of a casting can be closely controlled to meet design requirements for most applications. Available centrifugal casting alloys are shown in Tables 2, 3, and 4. Special compositions, not listed, can be prepared.

Electronic Package Design Eliminates Cabinet



U-SHAPED CHASSIS SECTIONS stacked one on top of the other form their own cabinet. Each U-shaped section is composed of two racks fastened to a common member in back. The racks hold transistorized printed-circuit boards.



HEADER PLATES on the ends of each rack serve the functions of a cabinet, including equipment protection and good appearance. The racks are placed far enough apart to permit access to printed boards.

ACCESS DOOR in the center closes the open part of the U. Removable sheet-metal sections cover the sides of the equipment.

The design approach is used by Consolidated Systems Corp., Monrovia, Calif., in the MicroSADIC—a high-speed digital processor. The design not only eliminates a cabinet per se, but sliding drawers and associated flexible cables are not needed.

Aluminum Construction and Air Cooling

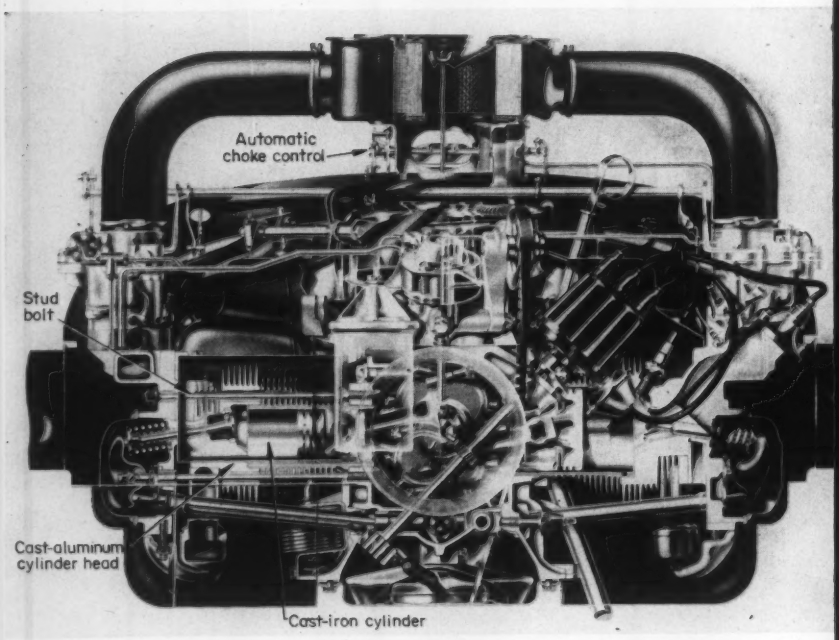
REAR MOUNTING of the horizontally opposed, six-cylinder engine in the 1960 Corvair is made possible primarily because the engine is built largely of aluminum alloy.

Cast in two halves with a vertical parting line, the aluminum-alloy crankcase is bolted together. Each half of the crankcase has three openings for the cast-iron cylinders. Each set of three cylinders is held in place by a cast-aluminum cylinder head, which contains all three combustion chambers for its bank. Twelve long studs—four to each cylinder—secure the head and its cylinders to the crankcase.

The pistons are made of cast aluminum alloy and are designed with two compression rings and one single-piece oil control ring.

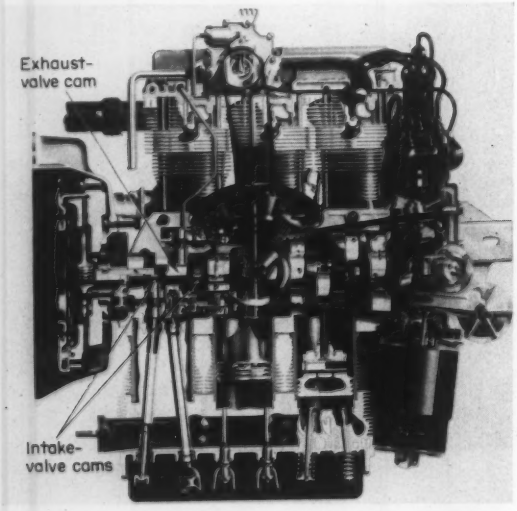
Automatic choke mechanism operates on an air-inlet pipe at the front of the air cleaner, instead of on the carburetors themselves. The flow of air during cold start and warmup is regulated before it passes through the air cleaner.

The large air tubes connecting the air cleaner to the two single-barrel carburetors are molded of fabric-reinforced rubber. These tubes are designed with coiled-wire inserts for rigidity.

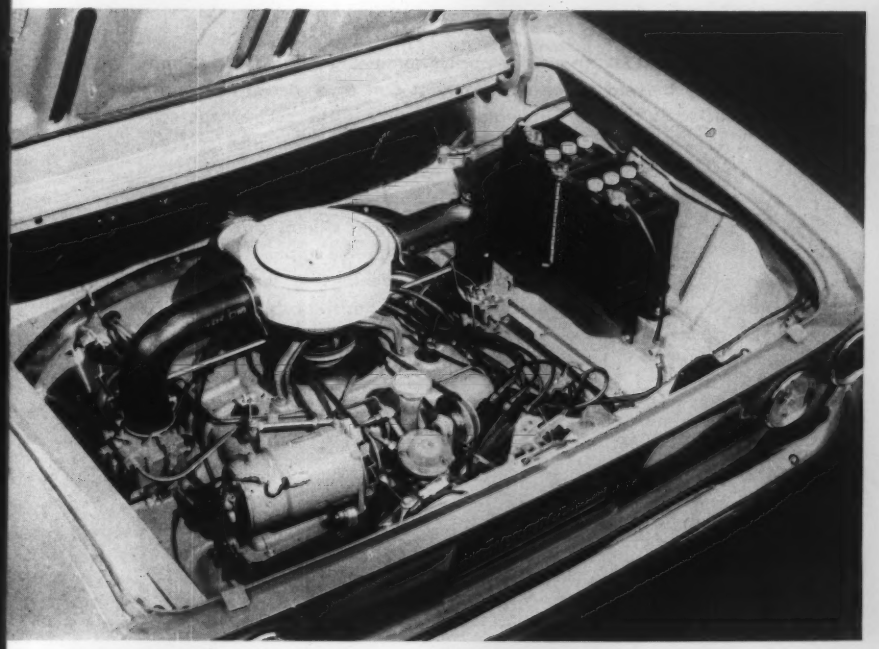


ENGINE CAMSHAFT is designed with only three exhaust-valve cams. Lobes on these cams are twice the width of the six intake-valve cams, permitting each exhaust-valve cam to actuate push rods for a pair of exhaust valves.

Push rods are housed by steel tubes between the crankcase and the cylinder head.

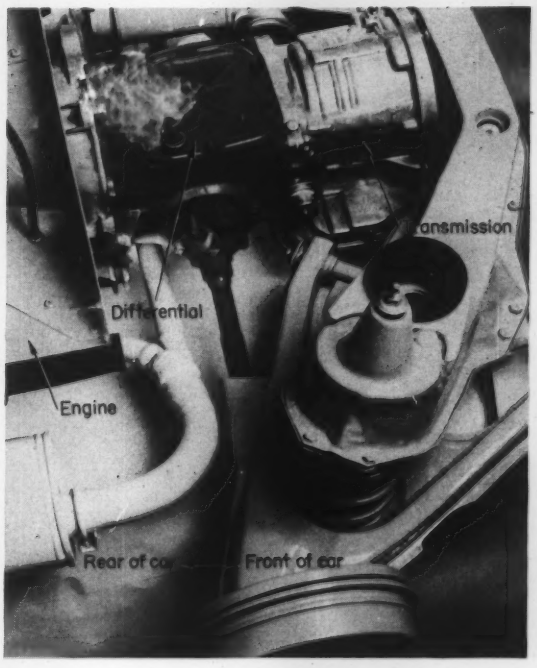


Cut Weight of New Corvair Engine

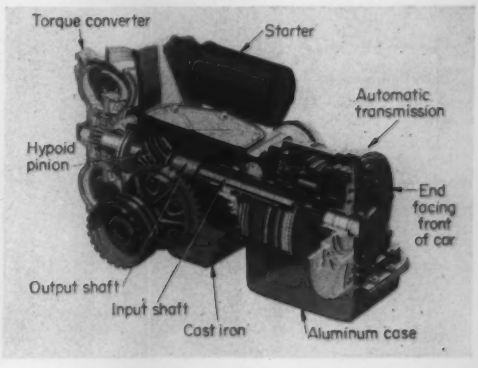


CENTRIFUGAL BLOWER mounted on top of the engine crankcase cover cools engine cylinders and heads. The blower is enclosed by a sheet-metal shroud that forms a plenum chamber. Directed downward by the fins of the heads and cylinders, the cooling air enters a duct under each bank and emerges at the rear of the engine.

The rate of engine cooling is regulated by a bellows thermostat in the lower part of the plenum. The bellows thermostat operates a damper ring which is similar to a tire rim in shape. This ring closes the blower air intake until the engine has reached its correct operating temperature.



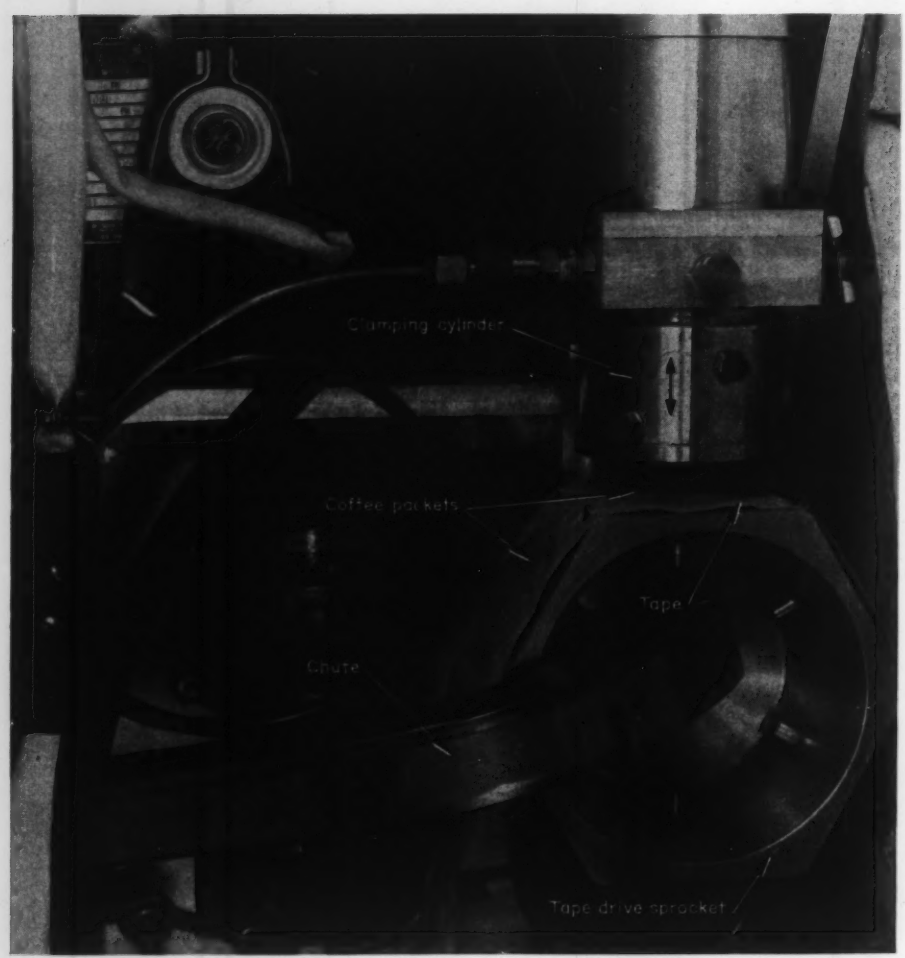
CONCENTRIC INPUT AND OUTPUT SHAFTS extend from the rear of the aluminum transmission case into the differential carrier. Made of cast iron, the differential carrier provides rigid support for the differential and hypoid pinion shafts. In addition, the clutch housing rear cover is cast integrally with the carrier, and the clutch release bearing pilot (or torque-converter stator mounting shaft in the case of the optional automatic transmission) is pressed into the carrier. Provision is also made for mounting the engine starter on the clutch housing rear cover.



Coffee in a Tape Brewed Automatically

HOT WATER FORCED through a packet containing ground coffee produces freshly brewed coffee. An integral part of a special tape, each coffee packet is airtight but water-penetrable. The coffee tape contains a series of holes which engage with teeth on a drive sprocket in a coffee machine designed by Rudd-Melikian Inc., Hatboro, Pa.

In operation, a fresh packet is moved under a cylinder in the machine when a coin is inserted. The cylinder clamps down against the tape and 210 F water is forced through the tape. The freshly brewed coffee runs through one of six openings in the tape drive sprocket and down an enclosed metal chute into the cup. The process can be repeated every 9 sec.

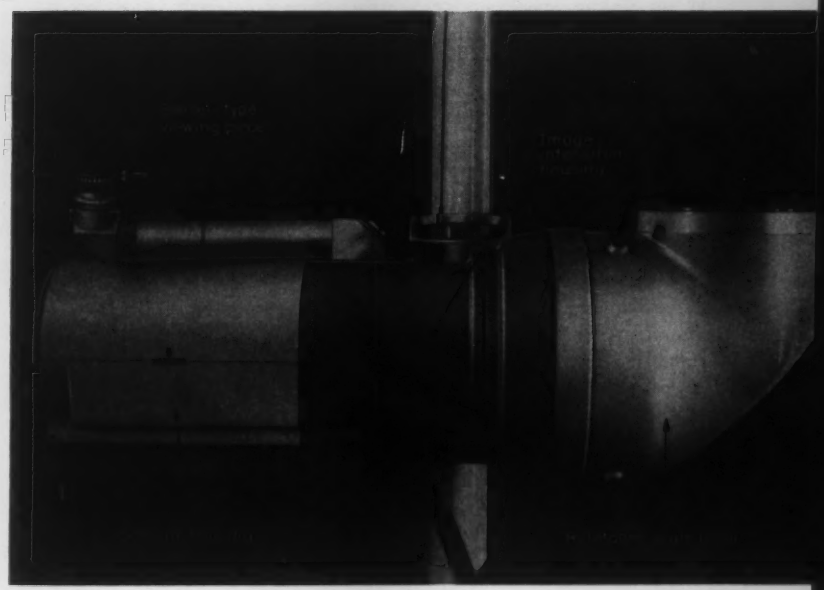


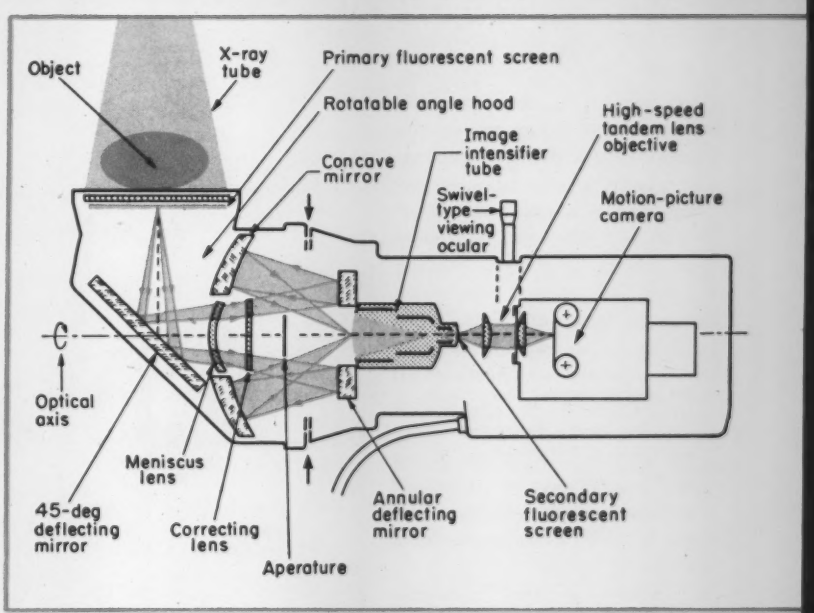
Large-Area X-Ray Images Projected to Movie Camera

HIGH-SPEED FOCUSING SYSTEM projects X-ray image, taken from primary fluorescent screen, on intensifier-tube photocathode to permit motion-picture recording without exceeding permissible radiation levels. Although electronic image intensification has been used previously for X-ray filming, the method has been limited to fluorescent screens not larger than the intensifier photocathode. Primary screen of this design is separated from photocathode and is 12½ in. in diameter. Focusing system consists of 45-deg deflecting mirror, meniscus lens, correcting lens, aperture, annular deflecting mirror, and annular concave mirror. Angle hood containing primary screen and 45-deg deflecting mirror may be rotated about optical axis for maximum versatility.

Recording system employs high-speed tandem lens objective with relative aperture of f0.75, projecting image from intensifier secondary fluorescent screen on 35-mm motion-picture film. Camera has 270-deg shutter opening, and 1 to 50 frames per sec may be taken. Cartridge holds nearly 400 ft of film to permit more than 6300 exposures with one loading. A mirror inserted in the tandem lens objective directs a small portion of the light beam to a swivel-type viewing ocular for continuous control.

The combination unit is a joint development of Siemens-Reiniger-Werke AG, Erlangen, Germany, and NV Optische Industrie De Oude, Delft, Holland.





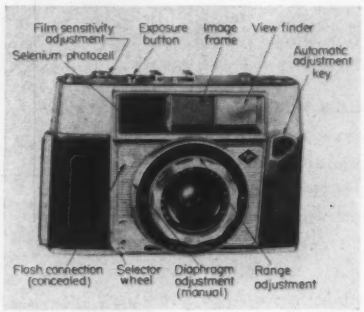
Spring-Wound Levers Scan Lightmeter Setting, Automatically Adjust Shutter Speed, Aperture

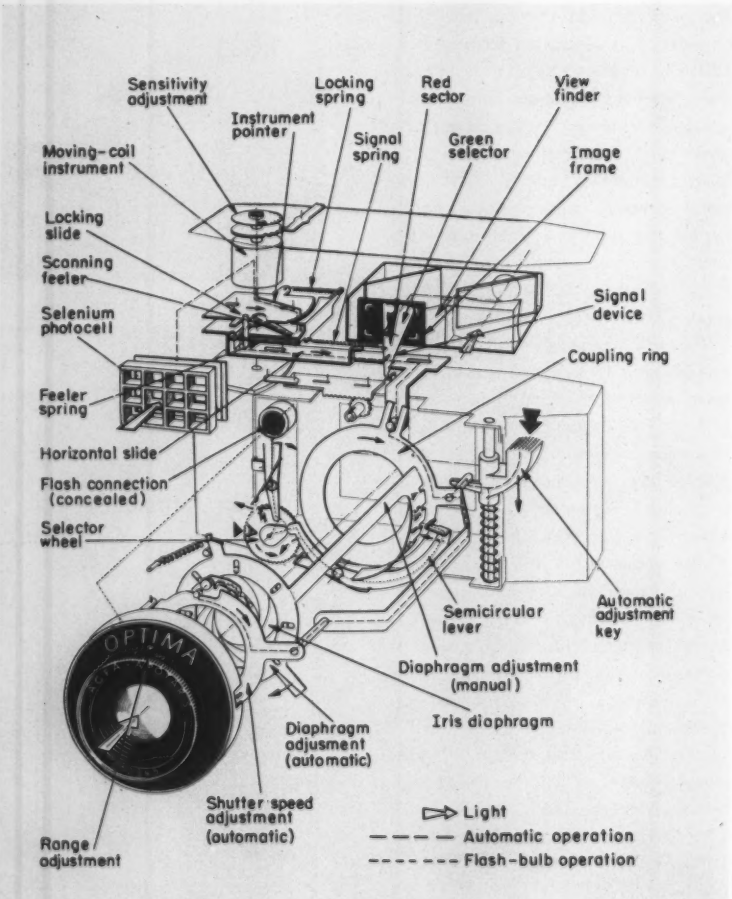
AUTOMATIC ADJUSTMENT KEY releases spring-wound lever system which "reads" lightmeter to set shutter speed and diaphragm aperture automatically. Incorporated in a 35-mm camera made by Agfa AG, Munich, Germany, the design uses a built-in lightmeter consisting of a selenium photocell and moving-coil instrument.

When the camera is pointed at the object to be photographed, the adjustment key is depressed and lever system released. A feeler spring starts to rotate the scanning feeler, while a vertical pin attached to a horizontal slide releases a locking slide. A toothed portion of the locking slide, through spring action, locks an instrument-pointer angular extension in position corresponding to object brightness. Feeler continues to rotate until it is stopped by pointer extension. Through vertical pin, feeler rotation is converted into horizontal slide movement. A coupling ring changes this sliding motion into rotary motion again. Coupling-ring rotary motion infinitely varies shutter speed from initial 1/30 to 1/250 sec, depending on object brightness. During speed adjustment, diaphragm remains open at f3.9. When 1/250 sec is reached, and only then, aperture is infinitely varied from initial f3.9 to f22, depending on object brightness. Entire process takes place during split second required to depress automatic adjustment key. Shutter is released by conventional exposure button.

Design includes slide-controlled signal device in viewfinder image frame, which displays red dot if object brightness is insufficient, green dot if picture is safe.

Selector wheel permits change from automatic to flashbulb operation. As wheel is turned, cam causes lever to open normally concealed flash connection. Another lever engages normally inoperative, manual diaphragm adjustment.





Modified Goodman diagrams simplify the

analysis of fatigue strength

LOUIS S. CLOCK
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College of Engineering
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DESIGNING life into machine parts requires a careful analysis of the stresses developed in the members under expected service conditions. Whether or not a given stress level will cause failure depends on the type of load application. Stresses which produce failure under repeated fluctuating loads may be harmless when the load is static.

Analysis of Stress: The stress which results from load combinations may be broken down into two components: 1. A steady component representing the average stress level. 2. An alternating component that tends to fatigue the metal. Hence, for a combination of steady and fatigue loads, the magnitude of the steady stress component and the amplitude of the alternating stress component are the important factors. The steady stress is referred to as average stress, S_{av}, of the cycle. The sum of the steady stress and alternating stress amplitude, $R/2$, is the maximum stress, S_{max}. Relationships between the steady and alternating components are shown in

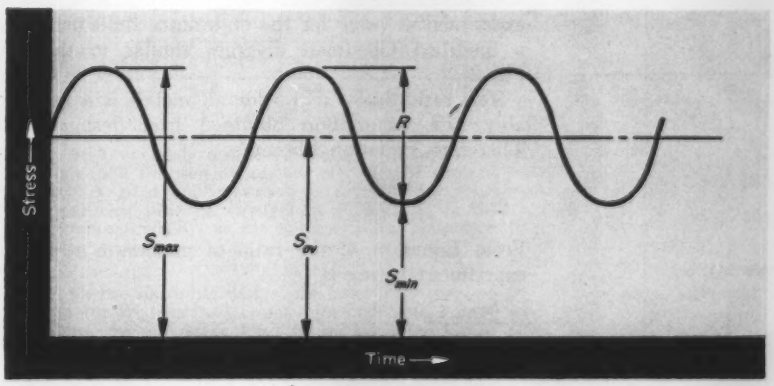


Fig. 1—For a combination of steady and fatigue loads, the magnitude of the steady stress component, S_{av}, plus the amplitude of the alternating stress component, S_r, produce the maximum stress, S_{max}.

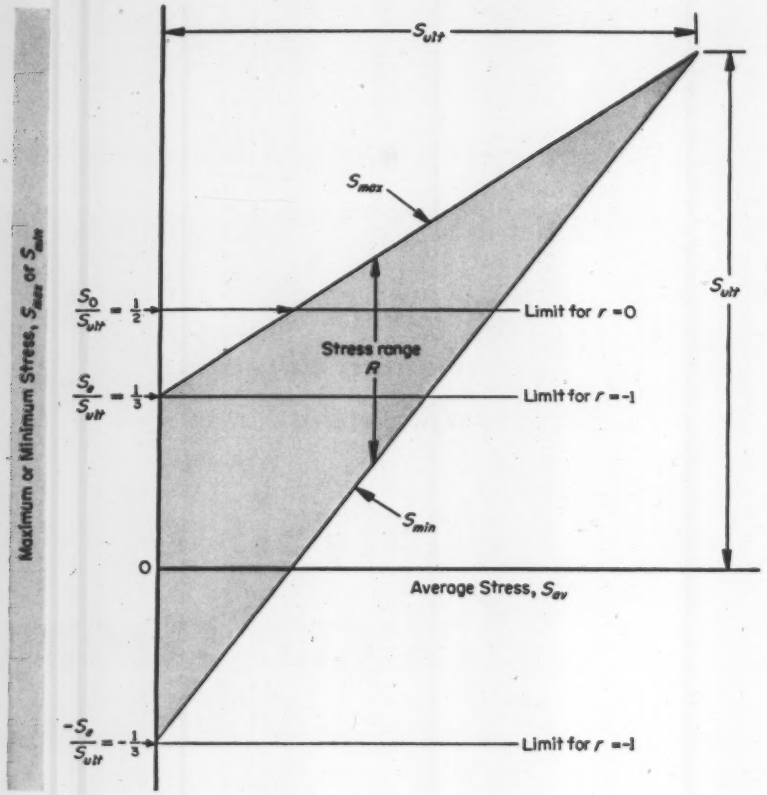


Fig. 2—Goodman diagram depicts the relationship between steady and fluctuating stresses. Diagram is an approximation based on an endurance limit of 1/3 the ultimate material strength.

Fig. 1 (see Nomenclature).

Maximum stress which a material can sustain depends upon the relationship between steady stress and alternating stress. A well-known method of depicting this relationship is the Goodman diagram, Fig. 2. It is an approximation, based on the average properties of materials commonly used at the time it was devised. The following relationships apply:

$$\frac{S_e}{S_{ult}} = \frac{1}{3} \tag{1}$$

$$\frac{S_0}{S_e} = \frac{0.5\,S_{ult}}{0.33\,S_{ult}} = 1.5 \tag{2}$$

$$S_{max} = \frac{0.5\,S_{ult}}{1 - 0.5\,r} \tag{3}$$

Nomenclature

S_{max} = Maximum stress, psi
S_{min} = Minimum stress, psi
S_{av} = Average stress, psi
S_r = Completely reversed stress, psi
R = Stress range (double amplitude), psi
= $S_{max} - S_{min}$
r = Stress range ratio
= S_{min}/S_{max}
S_0 = Endurance limit (no stress reversal), psi
S_e = Goodman endurance limit (complete stress reversal), psi
S_e' = Experimental endurance limit (complete stress reversal), psi

It is apparent that the permissible stress range, or algebraic difference between maximum and minimum stresses can be greater for reversed stresses than for stresses in one direction only, and decreases as the maximum stress is increased. When the maximum stress coincides with the ultimate stress the stress range is zero. Also, as the maximum stress is increased, the minimum stress must be increased algebraically in order that the material may be stressed indefinitely without fracture.

Modification of Goodman Diagram: The main criticism of the Goodman diagram is that all metals do not have the ratio S_e/S_{ult} equal to $\frac{1}{3}$. Therefore, an experimentally determined value, S_e' should be used instead of the Goodman value, S_e. Use of the experimental value for the endurance limit produces a modified Goodman diagram similar to that in Fig. 3.

The ratio $S_0/S_e = 1.5$ for all metals is a reasonably safe assumption obtained from test results. Therefore, Equation 3 becomes

$$S_{max} = \frac{1.5\,S_e'}{1 - 0.5\,r} \tag{4}$$

From Equation 4, the ratio of maximum stress to experimental stress is

$$\frac{S_{max}}{S_e'} = \frac{3}{2 - r} \tag{5}$$

Hence, when $r = 0$ in Equation 5, $S_{max}/S_e' = 1.5$.

Number of Cycles: For steel members, the concept of infinite life implies a minimum of 10 million load applications. The fatigue strength of the material at 1000 cycles is approximately 90 per cent of the ultimate strength, Fig. 4. From the figure, the lower end of the life line reaches the endurance limit at approximately one million cycles. The modified Goodman diagram similar to Fig. 3 can be used for combined static and alternating loads.

In problems involving finite life design, the alternating stress is determined from Fig. 4 for a specific number of cycles and is used instead of S_e' in constructing the modified Goodman diagram.

The procedure for using the modified Goodman diagram for infinite or finite life design is outlined in *Design Examples*.

design examples

Infinite Life: Material of a solid steel shaft has ultimate strength S_{ult} = 200,000 psi, and endurance limit S_e' = 64,000 psi for the machined surface. The shaft is subjected to a static pull which produces a constant stress S_{av} = 64,000 psi. If the shaft is to have infinite life, that is, a minimum of 10 million cycles, determine the maximum reversed stress, S_r, that may be developed in the shaft.

Construct a modified Goodman diagram, Fig. 3, from the given data for the shaft material by drawing the maximum stress line from the ultimate strength co-ordinates to the endurance limit on the zero average stress ordinate. To obtain the maximum stress the shaft can sustain, construct an ordinate from the given average stress to the maximum stress line. Hence, from Fig. 3, S_{max} = 107,500 psi for S_{av} = 64,000 psi. From Fig. 1, $S_{max} = S_{av} + R/2$. Hence, the reversed stress $R/2$ = 107,500 − 64,000 = 43,500 psi.

Finite Life: A shaft of the same material used in the *Infinite Life* example is subjected to a constant static stress, S_{av} = 80,000 psi. Determine the reversed stress, and the maximum stress that may be developed for 100,000 cycles.

Plot the life diagram, Fig. 4, on log-log co-ordinates. The reversed stress line is drawn from 90 per cent of the ultimate strength at 1000 cycles to the endurance limit S_e' at one million cycles. To obtain the reversed stress, erect an ordinate from 100,000 cycles to the S_r line. From Fig. 4, S_r = 90,000 psi.

Next, construct a modified Goodman diagram, Fig. 5, as described in the previous example, but using the value of S_r at 100,000 cycles, instead of S_e', on the maximum stress axis. To find S_{max}, erect an ordinate from S_{av} = 80,000 psi to the maximum stress line. From Fig. 5, S_{max} = 135,000 psi.

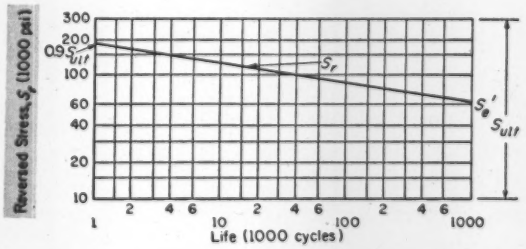


Fig. 4—Completely reversed stress, S_r, a material can sustain is a function of number of cycles of application. A good approximation is a shaft line from 90 per cent ultimate strength at 1000 cycles to the endurance limit, S_e', at one million cycles, plotted on log-log scales.

Fig. 5—For finite life design, the completely reversed stress for the expected cycles, obtained from Fig. 4, replaces the endurance limit in the modified Goodman diagram.

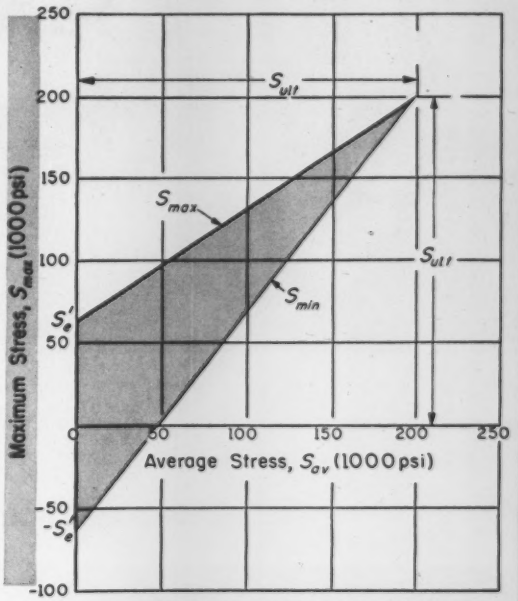
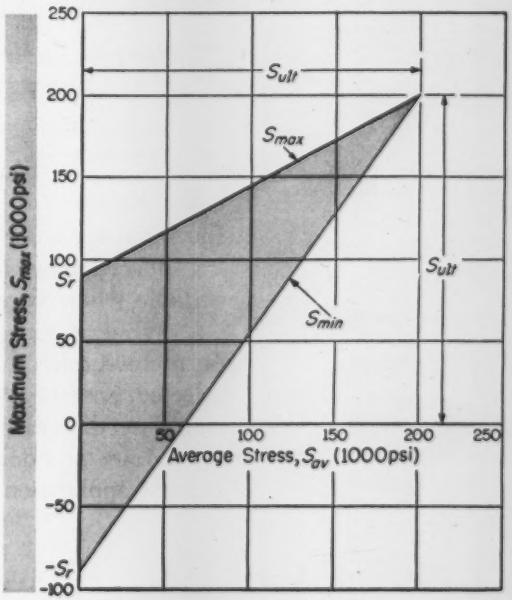


Fig. 3—Modified Goodman diagram is based on experimentally determined endurance limit. When designing for infinite life (more than 10 million load applications) the maximum stress line is drawn from the ultimate strength co-ordinates to the endurance limit. Maximum stress which the material can withstand is obtained by erecting an ordinate from the known average stress to the maximum stress line.



47 terminal designs for connecting

Basic design requirements which must be met in any electrical connection are:

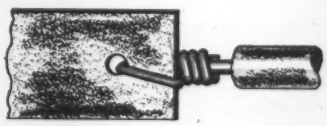
1. Sufficient contact area between wire and terminal to minimize surface resistance, and thus voltage drop and heat.
2. Adequate mechanical strength to withstand pulling of leads, etc.
3. Comparative ease and quickness of making (and unmaking) the connection.

Electrical wires are often "permanently" connected by soldering or crimping techniques. This approach is particularly suitable where currents are relatively low.

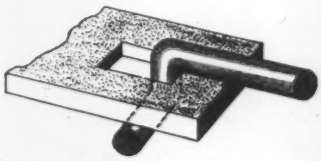
Where permanent connections are considered a design or maintenance disadvantage, detachable unions should be selected. Screw-fastened terminals and other wire-locking and clamping devices are available or can be made. Detachable unions are practically always required in medium and high-current applications.

electrical wires

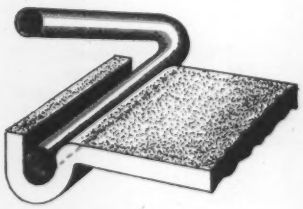
FEDERICO STRASSER
Santiago, Chile



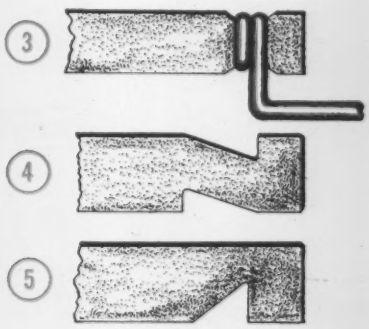
1 Punched-hole solder terminal with wrap-around wire



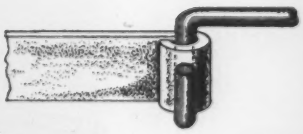
2 Pierced-hole solder terminal with hooked-under wire



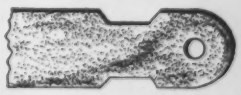
8 U-shaped crimped-end solder terminal



3 4 5 Notched solder terminals for wrap-around wire

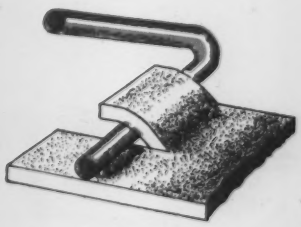


9 Curled-end solder terminal

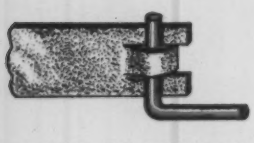


6 Combination punched-hole and notched solder terminal

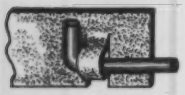
7 Combination punched-hole and notched solder terminal



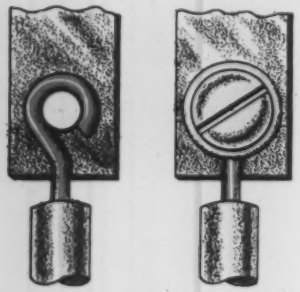
10 Slitted-end solder terminal



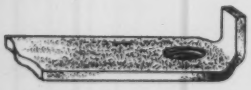
(11) Double slitted-end solder terminal



(12) Slitted-edge solder terminal

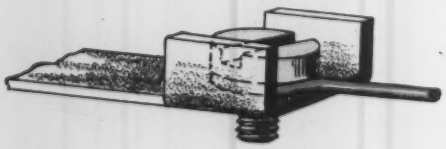


(14) Threaded flat terminal for screw fastener

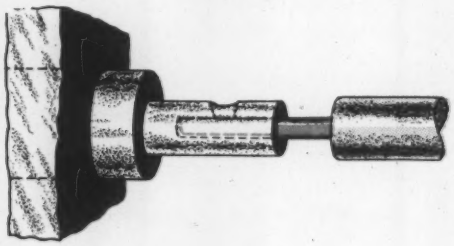


(17) Single-tab threaded terminal

(18) Bent-end threaded terminal

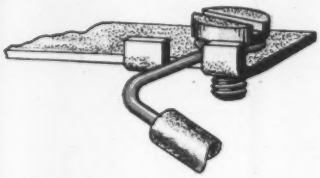


(19) Threaded terminal with bent-up side tabs

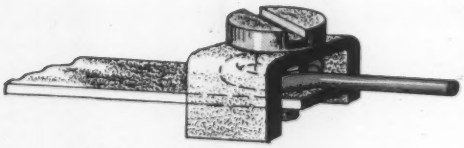


(13) Turned-end round terminal with solder hole

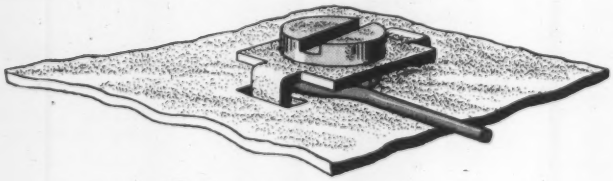
(15) Threaded terminal with bent-up corners to form wire guide



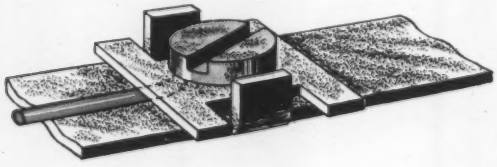
(16) Threaded terminal with bent-up tabs on one side



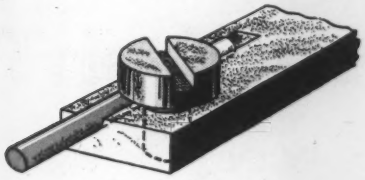
(20) Saddle washer and screw terminal



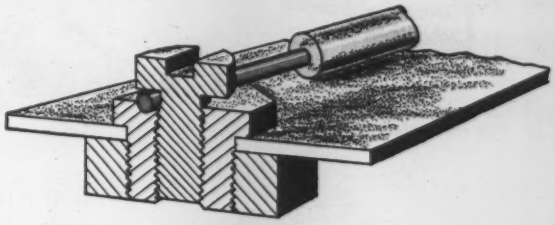
(21) Saddle washer and screw terminal



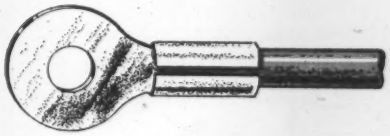
(22) Saddle washer and screw terminal



(23) Milled-slot threaded terminal

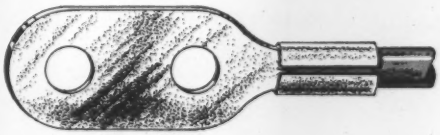


(24) Milled-slot bushing connection for thin terminals

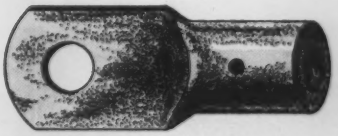


(25) Sheet-metal solder lug

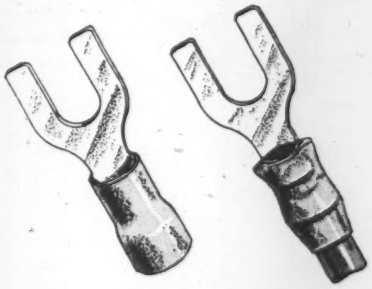
(30) Segmented eyelet lug



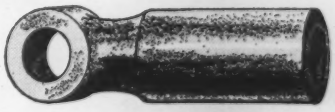
(26) Heavy-current solder lug



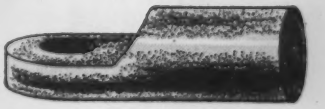
(31) Tubular cable socket



(27) Preinsulated compression terminal

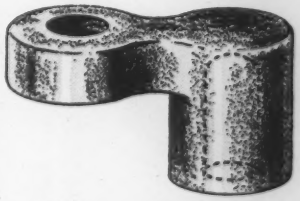


(32) Cast or pressed lug

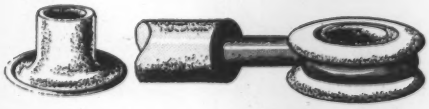


(33) Cast or pressed lug

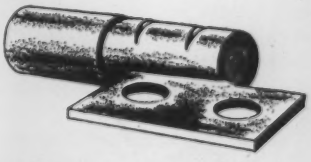
(28) Lateral open-eye solder lug



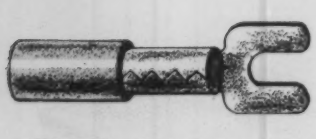
(34) Cast or pressed lug



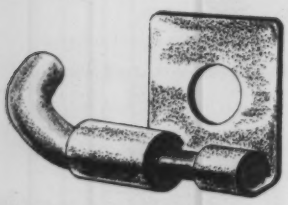
(29) Smooth eyelet lug



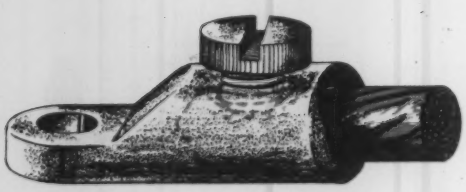
(35) Crimped curled-body lug



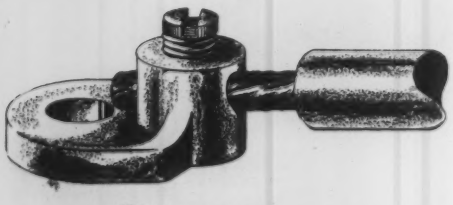
36 Crimped upward-bent sides with intermeshing teeth



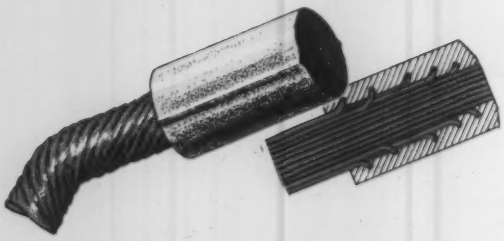
37 Double-crimping lug to wrap around both cable end and insulation



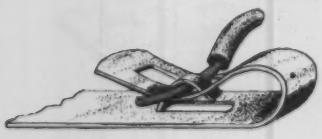
39 Screw-fastening lug for cable



40 Screw-fastening lug for cable

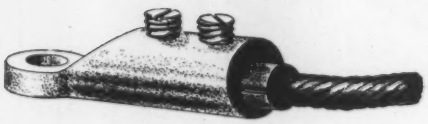


44 Bronze lug cast over cable end

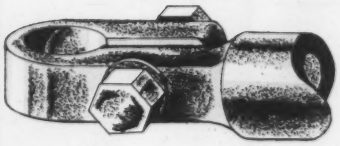


45 Spring-clip connector

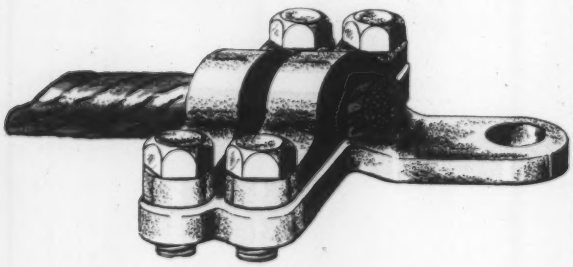
38 Insulation-piercing lug



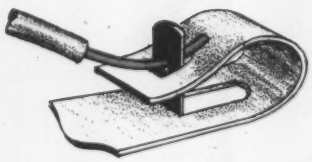
41 Double-screw cable connector



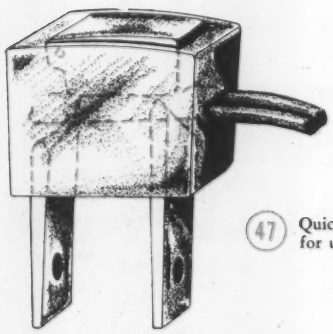
42 Storage-battery terminal



43 Clamp for large cable



46 Spring-clip connector



47 Quick-connect plug for unstripped wire

Trig-Type Cam Profiles

In cam design, determine first the performance required at significant points on cam profiles, then the manner of transition between them. This article provides convenient expressions for conditions at points and during transition periods. For the latter particularly, displacement tables derived with trigonometric functions simplify calculation of final cam profiles which minimize vibration due to cam action.

C. N. NEKLUTIN
Vice President
Universal Match Corp.
St. Louis, Mo.

Nomenclature

A = Subscript designating acceleration period
a = Acceleration, in. per sec^2 (translation) or rad per sec^2 (rotation)
b, c = Factors, numerical values of which are decimal portions of $T/2$ during which modified-trapezoid and modified-sine curves, respectively, have sine shape
C_A, C_D, C_v = Coefficients, all dimensionless, which represent max acceleration, max deceleration, and max velocity when S and T equal 1
D = Subscript designating deceleration period
d = Deceleration, in. per sec^2 (translation) or rad per sec^2 (rotation)
$f(t/T)$ = Function of t which varies from 0 to T
N = Speed of cam, rps
n = Number of selected and equal divisions of T in unity tables for determining cam displacement contour
P = Ratio $t_D/t_A = T_{II}/T_I = \alpha_D/\alpha_A$
S = Length of stroke, in. (translation) or rad (rotation)
s = Displacement, in. (translation) or rad (rotation)
T = Time for one stroke, $\alpha/(360\,N)$, sec
t = Time, sec
v = Velocity, ips (translation) or rad per sec (rotation)
α = Angular displacement of cam during one stroke, deg
I, II, III = Designations of principal curve shapes and performance: Dwell-rise-dwell, continuous reciprocating, dwell-rise-return

SELECTION of acceleration characteristics is the key feature and first step in this procedure for the design of cams. Plotted against time, selections of these characteristics comprise acceleration diagrams. One cycle of a diagram occurs in the time for one stroke or one cam revolution. All portions of a cycle must be expressed mathematically so that velocity characteristics can be obtained by one integration, and displacement characteristics by a second integration.

Basic equations for acceleration, velocity, and displacement are written in the form

$$\frac{a}{\frac{S}{T^2}} = C_A\left[f_a\left(\frac{t}{T}\right)\right] \quad (1)$$

$$\frac{v}{\frac{S}{T}} = C_v\left[f_v\left(\frac{t}{T}\right)\right] \quad (2)$$

$$\frac{s}{S} = f_s\left(\frac{t}{T}\right) \quad (3)$$

Performance Patterns: Diagrams are symmetrical when acceleration and deceleration curves have equal time periods, equal maximum values, and identical shapes. Examples are uniform acceleration and sine-curve acceleration.

Distinctive properties of all acceleration diagrams are established by values for coefficients C_A and C_v. Nonsymmetrical curves necessitate another coeffi-

cient C_D. All three coefficients are dimensionless and represent maximum values of acceleration, velocity, and deceleration when S and T equal 1.

Random acceleration diagrams can be evaluated by comparison with entirely symmetrical diagrams for which the values of coefficients are known. The smallest C_A occurs in uniform acceleration for which $C_A = C_D = 4$. For a sine-curve diagram (i.e., cycloidal), $C_A = C_D = 2\pi = 6.28$. It is advisable to use diagrams having values of C_A from 4 to 6.28.

Corresponding recommended values of C_v are shown in Fig. 1. Low C_v is desirable if a mass being moved is relatively large, and if it is necessary to decrease the amount of energy stored in the mass during the acceleration period. This consideration is especially important if the inertia load represents most of the total load on the driving means (motor).

Avoidance of vibration is a major design objective. Accordingly, acceleration curves should be continuous, that is, free of abrupt changes which cause vibration.

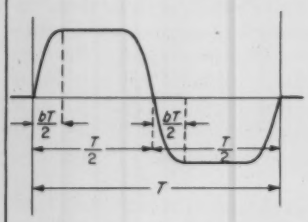
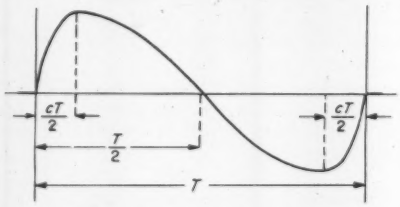
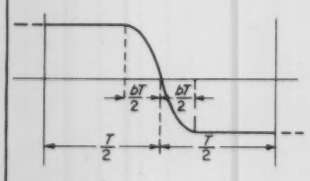
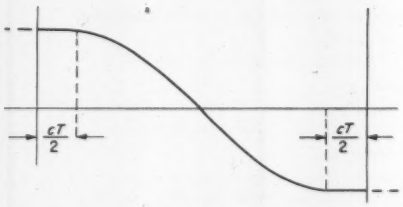
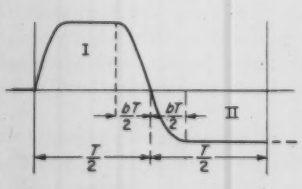
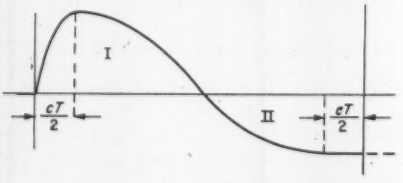
Another general rule is: The period during which acceleration changes from 0 to positive or negative maximum, should be longer than the period of free vibration of the cam follower system. That is, the system should have more than one period of free vibration during the change of acceleration from 0 to positive or negative maximum. Hence, the cam-follower system should be rigid so that its natural frequency is high.

If it is impossible to make the system sufficiently rigid, select an acceleration diagram which has the longest possible period of change of acceleration. A sine-curve diagram fills this requirement because the change both ways occurs during half the acceleration or deceleration periods. In this case of non-rigidity, a sine-curve diagram should be used despite high C_A. Comparison of vibrational stresses created by different acceleration diagrams indicates that sine curves have the best antivibration characteristics.*

Modified-Trapezoid Diagrams: To meet particular requirements, sine-curve diagrams can be modified

*C. N. Neklutin—"Vibration Analysis of Cams," MACHINE DESIGN, Vol. 26, No. 12, December, 1954, pp. 190-198. Also, *Transactions of the Second Conference on Mechanisms*, Penton Publishing Co., Cleveland, 1954, pp. 6-14.

Table 1 — Symmetrical Acceleration Diagrams

Type of Motion	Modified Trapezoid			Modified Sine			
		b	$C_A = C_D$		c	$C_A = C_D$	C_v
Type I dwell-rise-dwell		0	4.00		0.25	5.53	1.76
		0.15	4.49		0.50	6.28	2.00
		0.25	4.89				
		0.35	5.36				
		0.50	6.28				
Type II continuous reciprocating		0	4.00		0.25	4.48	1.63
		0.15	4.02		0.50	4.20	1.72
		0.25	4.05				
		0.35	4.10				
		0.50	4.20				
			C_A C_D			C_A C_D	
Type III dwell-rise-return		0	4.00 4.00		0.25	5.31 4.65	1.69
		0.15	4.37 4.12		0.50	5.81 4.52	1.85
		0.25	4.68 4.22				
		0.35	5.07 4.33				
		0.50	5.81 4.52				

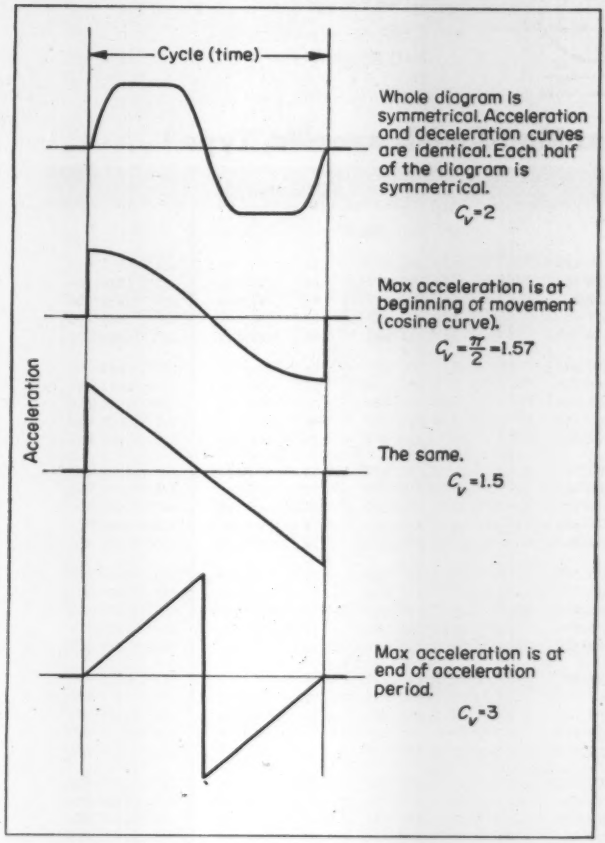

Cycle (time)
Acceleration
Whole diagram is symmetrical. Acceleration and deceleration curves are identical. Each half of the diagram is symmetrical.
C_v=2
Max acceleration is at beginning of movement (cosine curve).
$C_v = \frac{\pi}{2}$ =1.57
The same.
C_v=1.5
Max acceleration is at end of acceleration period.
C_v=3

Fig. 1—How shapes of acceleration curves affect velocity coefficient C_v.

by introducing a period of constant acceleration between sine quadrants. Portions of the sine curve are compressed into shorter time intervals. An objective and result is a decrease in C_A. From their appearance, these diagrams are called "modified trapezoid," Table 1. Duration of compressed sine periods is expressed as a factor b of $T/2$.

Values of b range from 0 to 0.5. Value 0 creates a uniform-acceleration diagram. Value 0.50 creates a sine-curve diagram. Corresponding values of C_A are 4.00 and 6.28. Avoid the lower values where acceleration changes abruptly. Experience indicates that $b = 0.25$ is satisfactory for speeds up to 750 rpm. Properties of basic acceleration diagrams appear in Table 1.

Analysis of torque on cam shafts indicates that for a modified trapezoid diagram I, cam torque reaches its maximum positive value at approximately 0.4 T, and its maximum negative value at approximately 0.6 T. That is, torque changes from maximum positive to maximum negative in $T/5$.

Despite their versatility, modified trapezoid diagrams are not satisfactory when large masses must

Table 2—Operations Common for the Use of Unity Displacement Tables

Operation	Equation(s)
1. Select P	4, 5, 6
2. Determine actual stroke S; then	
a. Calculate s_A	$s_A = \frac{1}{1+P} S$
b. Calculate s_D	$s_D = \frac{P}{1+P} S$
3. Calculate displacements for n equal angular increments, 180 or less:	
a. Multiply master unity table I_A or II_A by s_A.	
b. Multiply master unity tables II_D or I_D by s_D.	
c. Connect the s_D curve to the s_A curve.	
Certain equations common to diagram types, I, II, and III:	$a_{max} = C_A \frac{S}{T^2}$ $d_{max} = C_D \frac{S}{T^2}$ $v_{max} = C_v \frac{S}{T}$

be moved by a cam follower at high speed. Modified-sine diagrams solve this problem.

Modified-Sine Diagrams: Combinations of sine and cosine curves have been suggested by E. H. Schmidt of Du Pont. Essentially, Schmidt combinations are sine curves in which quadrants occupy unequal periods of time. For that reason, they are called "modified sine," Table 1. Advantages are:

When $b = 0.25$:

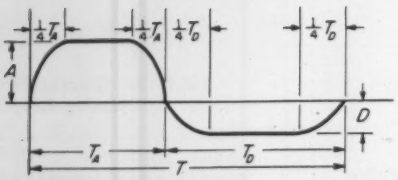
1. Maximum positive torque on the cam shaft is reached at 0.29 T; maximum negative torque at 0.71 T. Therefore, change from extreme torque limits occurs during 0.42 T. The corresponding period for a modified trapezoid is 0.2 T.
2. Maximum cam torque is only slightly more than 2/3 the cam torque created by the modified trapezoid.
3. C_v is about 12 per cent lower than the modified trapezoid value, so energy stored in the moving mass is decreased substantially.
4. Vibration characteristics of the cam follower system are nearly the same for modified-sine and modified-trapezoid diagrams.

There appears to be only one defect. The maximum acceleration coefficient is 13 per cent higher than for a modified trapezoid.

For use with modified-sine diagrams, a factor c, similar to factor b, is introduced. When $c = 0$, diagram I is a cosine curve with $C_A = C_D = \pi 2/2 = 4.935$, and $C_v = \pi/2 = 1.571$. When $c = 0.5$, diagram I is a sine curve having $C_A = C_D = 2\pi = 6.283$, and $C_v = 2$. Therefore, when $b = c = 0.5$, modified-sine and modified-trapezoid diagrams are identical.

Common properties of trigonometric diagrams are apparent in Table 1. Each group of diagrams has three forms to meet all possible cam design requirements. For each selected value of b and c there are two modified shapes: Types I and II. Types III are

DATA SHEET



$C_a = 4.8881 \frac{1+\rho}{2}$

$C_b = 4.8881 \frac{1+\rho}{2\rho}$

$C_v = 2$

$b = 0.25$

Table 3—Unity-Displacement Modified-Trapezoid, Type I

V/V_{max}

Acceleration			Acceleration				Deceleration			
0	.0000		0	.000 000			0	.000 000		
6	.0043		1	.000 000	61	.079 569	121	.417 429	1	.011 111
12	.0168		2	.000 004	62	.082 975	122	.425 360	2	.022 219
18	.0372		3	.000 012	63	.086 456	123	.433 367	3	.033 322
24	.0644		4	.000 028	64	.090 013	124	.441 450	4	.044 416
30	.0973		5	.000 055	65	.093 645	125	.449 608	5	.055 501
36	.1344		6	.000 095	66	.097 352	126	.457 842	6	.066 572
42	.1742		7	.000 150	67	.101 135	127	.466 150	7	.077 628
48	.2216		8	.000 224	68	.104 993	128	.474 535	8	.088 665
54	.2624		9	.000 318	69	.108 927	129	.482 995	9	.099 682
60	.3031		10	.000 436	70	.112 936	130	.491 530	10	.110 675
66	.3303		11	.000 580	71	.117 021	131	.500 140	11	.121 642
72	.3846		12	.000 752	72	.121 181	132	.508 826	12	.132 582
78	.4253		13	.000 954	73	.125 416	133	.517 588	13	.143 490
84	.4661		14	.001 190	74	.129 727	134	.526 425	14	.154 366
90	.5068		15	.001 461	75	.134 113	135	.535 337	15	.165 206
96	.5475		16	.001 770	76	.138 575	136	.544 325	16	.176 008
102	.5883		17	.002 118	77	.143 112	137	.553 388	17	.186 720
108	.6290		18	.002 509	78	.147 725	138	.562 527	18	.197 491
114	.6697		19	.002 945	79	.152 413	139	.571 740	19	.208 167
120	.7105		20	.003 426	80	.157 177	140	.581 028	20	.218 796
126	.7444		21	.003 956	81	.162 015	141	.590 391	21	.229 377
132	.7919		22	.004 537	82	.166 930	142	.599 827	22	.239 907
138	.8258		23	.005 170	83	.171 920	143	.609 336	23	.250 386
144	.8656		24	.005 857	84	.176 985	144	.618 918	24	.260 809
150	.9027		25	.006 601	85	.182 126	145	.628 572	25	.271 177
156	.9356		26	.007 402	86	.187 342	146	.638 296	26	.281 487
162	.9628		27	.008 262	87	.192 633	147	.648 091	27	.291 738
168	.9831		28	.009 184	88	.198 000	148	.657 954	28	.301 927
174	.9957		29	.010 168	89	.203 443	149	.667 885	29	.312 054
180	1.0000		30	.011 216	90	.208 960	150	.677 883	30	.322 117
	1.0000	0	31	.012 330	91	.214 554	151	.687 946	31	.332 115
	.9957	6	32	.013 510	92	.220 222	152	.698 073	32	.342 046
	.9831	12	33	.014 757	93	.225 966	153	.708 262	33	.351 909
	.9628	18	34	.016 074	94	.231 786	154	.718 513	34	.361 704
	.9356	24	35	.017 461	95	.237 681	155	.728 823	35	.371 428
	.9027	30	36	.018 918	96	.243 652	156	.739 191	36	.381 082
	.8656	36	37	.020 447	97	.249 697	157	.749 614	37	.390 664
	.8258	42	38	.022 049	98	.255 819	158	.760 093	38	.400 173
	.7919	48	39	.023 724	99	.262 015	159	.770 623	39	.409 609
	.7444	54	40	.025 473	100	.268 288	160	.781 204	40	.418 972
	.7105	60	41	.027 296	101	.274 635	161	.791 833	41	.428 260
	.6697	66	42	.029 193	102	.281 058	162	.802 509	42	.437 473
	.6290	72	43	.031 166	103	.287 557	163	.813 230	43	.446 612
	.5883	78	44	.033 214	104	.294 131	164	.823 992	44	.455 675
	.5475	84	45	.035 337	105	.300 780	165	.834 794	45	.464 663
	.5068	90	46	.037 536	106	.307 505	166	.845 634	46	.473 575
	.4661	96	47	.039 810	107	.314 305	167	.856 510	47	.482 412
	.4253	102	48	.042 160	108	.321 181	168	.867 418	48	.491 174
	.3846	108	49	.044 585	109	.328 132	169	.878 358	49	.499 860
	.3303	114	50	.047 085	110	.335 158	170	.889 325	50	.508 420
	.3031	120	51	.049 661	111	.342 260	171	.900 318	51	.517 005
	.2624	126	52	.052 313	112	.349 438	172	.911 335	52	.525 465
	.2216	132	53	.055 039	113	.356 690	173	.922 372	53	.533 850
	.1742	138	54	.057 842	114	.364 019	174	.933 428	54	.542 158
	.1344	144	55	.060 719	115	.371 422	175	.944 499	55	.550 392
	.0973	150	56	.063 672	116	.378 901	176	.955 584	56	.558 520
	.0644	156	57	.066 701	117	.386 456	177	.966 678	57	.566 633
	.0372	162	58	.069 805	118	.394 086	178	.977 781	58	.574 640
	.0168	168	59	.072 984	119	.401 791	179	.988 889	59	.582 571
	.0043	174	60	.076 239	120	.409 572	180	1.000 000	60	.590 428
	.0000	180								

Deceleration			
1	.598 209	121	.927 016
2	.605 914	122	.930 195
3	.613 544	123	.933 299
4	.621 099	124	.936 328
5	.628 578	125	.939 281
6	.635 981	126	.942 158
7	.643 310	127	.944 961
8	.650 562	128	.947 687
9	.657 740	129	.950 339
10	.664 842	130	.952 915
11	.671 868	131	.955 415
12	.678 819	132	.957 840
13	.685 695	133	.960 190
14	.692 495	134	.962 434
15	.699 220	135	.964 663
16	.755 869	136	.966 786
17	.712 443	137	.968 834
18	.718 942	138	.970 807
19	.725 365	139	.972 704
20	.731 712	140	.974 527
21	.737 985	141	.976 276
22	.744 181	142	.977 951
23	.750 303	143	.979 553
24	.756 348	144	.981 082
25	.762 319	145	.982 539
26	.768 214	146	.983 926
27	.774 034	147	.985 243
28	.779 778	148	.986 490
29	.785 446	149	.987 670
30	.791 040	150	.988 784
31	.796 557	151	.989 832
32	.802 000	152	.990 816
33	.807 367	153	.991 738
34	.812 658	154	.992 598
35	.817 874	155	.993 399
36	.823 015	156	.994 143
37	.828 080	157	.994 830
38	.833 070	158	.995 463
39	.837 985	159	.996 044
40	.842 823	160	.996 574
41	.847 587	161	.997 055
42	.852 275	162	.997 491
43	.856 888	163	.997 882
44	.861 425	164	.998 230
45	.865 887	165	.998 539
46	.870 273	166	.998 810
47	.874 584	167	.999 046
48	.878 819	168	.999 248
49	.882 979	169	.999 420
50	.887 064	170	.999 564
51	.891 073	171	.999 682
52	.895 007	172	.999 776
53	.898 865	173	.999 850
54	.902 648	174	.999 905
55	.906 355	175	.999 945
56	.909 987	176	.999 972
57	.913 544	177	.999 988
58	.917 025	178	.999 996
59	.920 431	179	1.000 000
60	.923 761	180	1.000 000

Deceleration

$C_A = 5.5280 \frac{1+P}{2}$

$C_D = 5.5280 \frac{1+P}{2P}$

$C_V = 1.7596$

$c = 0.25$

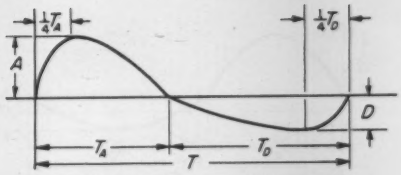
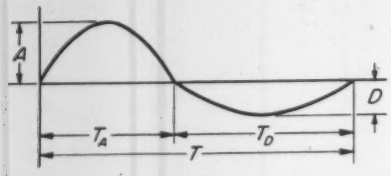


Table 4—Unity-Displacement Modified-Sine, Type I

V/V_{max}	Acceleration		Acceleration			Deceleration			Deceleration
0	.0000	0	.000 000			0	.000 000		
6	.0055	1	.000 000	61	.089 953	121	.456 426	1	.009 776	61	.559 694	121	.917 481
12	.0217	2	.000 004	62	.093 796	122	.464 568	2	.019 550	62	.567 672	122	.921 072
18	.0478	3	.000 014	63	.097 722	123	.472 762	3	.029 322	63	.575 592	123	.924 578
24	.0828	4	.000 032	64	.101 732	124	.481 010	4	.039 092	64	.583 456	124	.928 001
30	.1250	5	.000 062	65	.105 825	125	.489 310	5	.048 858	65	.591 262	125	.931 338
36	.1779	6	.000 107	66	.110 001	126	.497 659	6	.058 618	66	.599 009	126	.934 590
42	.2239	7	.000 170	67	.114 260	127	.506 059	7	.068 373	67	.606 698	127	.937 758
48	.2762	8	.000 253	68	.118 602	128	.514 509	8	.078 120	68	.614 326	128	.940 841
54	.3283	9	.000 360	69	.123 026	129	.523 007	9	.087 860	69	.621 893	129	.943 839
60	.3802	10	.000 493	70	.127 531	130	.531 553	10	.097 591	70	.629 399	130	.946 752
66	.4314	11	.000 656	71	.132 119	131	.540 146	11	.107 312	71	.636 844	131	.949 580
72	.4818	12	.000 850	72	.136 788	132	.548 785	12	.117 021	72	.644 225	132	.952 322
78	.5310	13	.001 079	73	.141 537	133	.557 468	13	.126 720	73	.651 543	133	.954 979
84	.5788	14	.001 346	74	.146 368	134	.566 197	14	.136 405	74	.658 797	134	.957 551
90	.6250	15	.001 652	75	.151 280	135	.574 969	15	.146 076	75	.665 986	135	.960 037
96	.6694	16	.002 001	76	.156 271	136	.583 783	16	.155 733	76	.673 110	136	.962 438
102	.7117	17	.002 396	77	.161 342	137	.592 640	17	.165 374	77	.680 168	137	.964 753
108	.7518	18	.002 838	78	.166 493	138	.601 536	18	.174 998	78	.687 158	138	.966 985
114	.7895	19	.003 330	79	.171 723	139	.610 474	19	.184 604	79	.694 083	139	.969 131
120	.8245	20	.003 875	80	.177 032	140	.619 450	20	.194 192	80	.700 939	140	.971 193
126	.8568	21	.004 474	81	.182 419	141	.628 465	21	.203 760	81	.707 726	141	.973 171
132	.8860	22	.005 131	82	.187 884	142	.637 517	22	.213 307	82	.714 445	142	.975 065
138	.9117	23	.005 847	83	.193 426	143	.646 606	23	.222 833	83	.721 095	143	.976 876
144	.9351	24	.006 624	84	.199 046	144	.655 730	24	.232 336	84	.727 673	144	.978 606
150	.9548	25	.007 465	85	.204 742	145	.664 889	25	.241 816	85	.734 182	145	.980 254
156	.9709	26	.008 371	86	.210 514	146	.674 082	26	.251 271	86	.740 619	146	.981 822
162	.9836	27	.009 344	87	.216 362	147	.683 307	27	.260 700	87	.746 984	147	.983 311
168	.9927	28	.010 386	88	.222 286	148	.692 565	28	.270 104	88	.753 277	148	.984 722
174	.9982	29	.011 499	89	.228 284	149	.701 853	29	.279 480	89	.759 497	149	.986 057
180	1.0000	30	.012 684	90	.234 357	150	.711 172	30	.288 828	90	.765 643	150	.987 316
	1.0000 0	31	.013 943	91	.240 503	151	.720 520	31	.298 147	91	.771 716	151	.988 501
	.9982 6	32	.015 278	92	.246 723	152	.729 896	32	.307 435	92	.777 714	152	.989 614
	.9927 12	33	.016 689	93	.253 016	153	.739 300	33	.316 693	93	.783 638	153	.990 656
	.9836 18	34	.018 178	94	.259 381	154	.748 729	34	.325 918	94	.789 486	154	.991 629
	.9709 24	35	.019 746	95	.265 818	155	.758 184	35	.335 111	95	.795 258	155	.992 535
	.9548 30	36	.021 394	96	.272 327	156	.767 664	36	.344 270	96	.800 954	156	.993 376
	.9351 36	37	.023 124	97	.278 905	157	.777 167	37	.353 394	97	.806 574	157	.994 153
	.9117 42	38	.024 935	98	.285 555	158	.786 693	38	.362 483	98	.812 116	158	.994 869
	.8860 48	39	.026 829	99	.292 274	159	.796 240	39	.371 535	99	.817 581	159	.995 526
	.8568 54	40	.028 807	100	.299 061	160	.805 808	40	.380 550	100	.822 968	160	.996 125
	.8245 60	41	.030 869	101	.305 917	161	.815 396	41	.389 526	101	.828 277	161	.996 670
	.7895 66	42	.033 015	102	.312 842	162	.825 002	42	.398 464	102	.833 507	162	.997 162
	.7518 72	43	.035 246	103	.319 832	163	.834 626	43	.407 360	103	.838 658	163	.997 604
	.7117 78	44	.037 562	104	.326 890	164	.844 267	44	.416 217	104	.843 729	164	.997 999
	.6694 84	45	.039 963	105	.334 014	165	.853 924	45	.425 031	105	.848 720	165	.998 348
	.6250 90	46	.042 449	106	.341 203	166	.863 595	46	.433 803	106	.853 632	166	.998 654
	.5788 96	47	.045 021	107	.348 457	167	.873 280	47	.442 532	107	.858 463	167	.998 921
	.5310 102	48	.047 678	108	.355 775	168	.882 979	48	.451 215	108	.863 212	168	.999 150
	.4818 108	49	.050 420	109	.363 156	169	.892 688	49	.459 854	109	.867 881	169	.999 344
	.4314 114	50	.053 248	110	.370 601	170	.902 409	50	.468 447	110	.872 469	170	.999 507
	.3802 120	51	.056 161	111	.378 107	171	.912 140	51	.476 993	111	.876 974	171	.999 640
	.3283 126	52	.059 159	112	.385 674	172	.921 880	52	.485 491	112	.881 398	172	.999 747
	.2762 132	53	.062 242	113	.393 302	173	.931 627	53	.493 941	113	.885 740	173	.999 830
	.2239 138	54	.065 410	114	.400 991	174	.941 382	54	.502 341	114	.889 999	174	.999 893
	.1779 144	55	.068 662	115	.408 738	175	.951 142	55	.510 690	115	.894 175	175	.999 938
	.1250 150	56	.071 999	116	.416 544	176	.960 908	56	.518 990	116	.898 268	176	.999 968
	.0828 156	57	.075 422	117	.424 408	177	.970 678	57	.527 238	117	.902 278	177	.999 986
	.0478 162	58	.078 928	118	.432 328	178	.980 450	58	.535 432	118	.906 204	178	.999 996
	.0217 168	59	.082 519	119	.440 306	179	.990 224	59	.543 574	119	.910 047	179	1.000 000
	.0055 174	60	.086 194	120	.448 338	180	1.000 000	60	.551 662	120	.913 806	180	1.000 000
	.0000 180												

Deceleration	Acceleration



$C_A = 6.2832 \frac{1+\rho}{2}$
$C_D = 6.2832 \frac{1+\rho}{2\rho}$
$C_V = 2$
$c = 0.50$

Table 5—Unity-Displacement Sine, Type I

V/V_{max}

Acceleration		Acceleration				Deceleration			
0 .0000		0 .000 000				0 .000 000			
6 .0028		1 .000 000	61 .060 489	121 .399 377		2 .011 111	61 .617 289	121 .945 067	
12 .0110		2 .000 002	62 .063 394	122 .407 836		2 .022 220	62 .625 495	122 .947 720	
18 .0245		3 .000 008	63 .066 384	123 .416 376		3 .033 326	63 .633 616	123 .950 290	
24 .0432		4 .000 018	64 .069 460	124 .424 998		4 .044 426	64 .641 651	124 .952 780	
30 .0670		5 .000 035	65 .072 624	125 .433 700		5 .055 520	65 .649 598	125 .955 189	
36 .0955		6 .000 061	66 .075 876	126 .442 482		6 .066 606	66 .657 457	126 .957 518	
42 .1239		7 .000 097	67 .079 216	127 .451 342		7 .077 681	67 .665 228	127 .959 769	
48 .1655		8 .000 144	68 .082 646	128 .460 279		8 .088 745	68 .672 910	128 .961 943	
54 .2061		9 .000 205	69 .086 165	129 .469 293		9 .099 795	69 .680 501	129 .964 040	
60 .2500		10 .000 282	70 .089 775	130 .478 383		10 .110 830	70 .688 002	130 .966 062	
66 .2966		11 .000 375	71 .093 476	131 .487 546		11 .121 848	71 .695 412	131 .968 009	
72 .3455		12 .000 486	72 .097 269	132 .496 783		12 .132 847	72 .702 731	132 .969 884	
78 .3960		13 .000 618	73 .101 154	133 .506 092		13 .143 826	73 .709 957	133 .971 686	
84 .4477		14 .000 772	74 .105 132	134 .515 471		14 .154 784	74 .717 090	134 .973 418	
90 .5000		15 .000 949	75 .109 203	135 .524 921		15 .165 718	75 .724 130	135 .975 079	
96 .5523		16 .001 151	76 .113 367	136 .534 439		16 .176 627	76 .731 077	136 .976 672	
102 .6039		17 .001 380	77 .117 626	137 .544 024		17 .187 509	77 .737 930	137 .978 198	
108 .6545		18 .001 637	78 .121 979	138 .553 676		18 .198 363	78 .744 687	138 .979 658	
114 .7034		19 .001 924	79 .126 427	139 .563 392		19 .209 187	79 .751 351	139 .981 052	
120 .7500		20 .002 224	80 .130 970	140 .573 172		20 .219 980	80 .757 919	140 .982 384	
126 .7939		21 .002 595	81 .135 609	141 .583 014		21 .230 739	81 .764 391	141 .983 652	
132 .8345		22 .002 981	82 .140 343	142 .592 918		22 .241 463	82 .770 768	142 .984 860	
138 .8716		23 .003 404	83 .145 174	143 .602 881		23 .252 151	83 .777 048	143 .986 008	
144 .9045		24 .003 865	84 .150 100	144 .612 902		24 .262 802	84 .783 233	144 .987 098	
150 .9330		25 .004 365	85 .155 124	145 .622 980		25 .273 412	85 .789 321	145 .988 131	
156 .9567		26 .004 907	86 .160 243	146 .633 114		26 .283 982	86 .795 312	146 .989 108	
162 .9755		27 .005 490	87 .165 460	147 .643 303		27 .294 510	87 .801 207	147 .990 031	
168 .9890		28 .006 118	88 .170 773	148 .653 544		28 .304 993	88 .807 005	148 .990 901	
174 .9972		29 .006 791	89 .176 183	149 .663 836		29 .315 431	89 .812 706	149 .991 720	
180 1.0000		30 .007 512	90 .181 690	150 .674 178		30 .325 822	90 .818 310	150 .992 488	
1.0000	0	31 .008 280	91 .187 294	151 .684 569		31 .336 164	91 .823 817	151 .993 209	
.9972	6	32 .009 099	92 .192 995	152 .695 007		32 .346 456	92 .829 227	152 .993 882	
.9890	12	33 .009 969	93 .198 793	153 .705 490		33 .356 697	93 .834 540	153 .994 510	
.9755	18	34 .010 892	94 .204 688	154 .716 018		34 .366 886	94 .839 757	154 .995 093	
9567	24	35 .011 869	95 .210 679	155 .726 588		35 .377 020	95 .844 876	155 .995 635	
.9330	30	36 .012 902	96 .216 767	156 .737 198		36 .387 098	96 .849 900	156 .996 135	
.9045	36	37 .013 992	97 .222 952	157 .747 849		37 .397 119	97 .854 826	157 .996 596	
.8716	42	38 .015 140	98 .229 232	158 .758 537		38 .407 082	98 .859 657	158 .997 019	
.8345	48	39 .016 348	99 .235 609	159 .769 261		39 .416 986	99 .864 391	159 .997 405	
.7939	54	40 .017 616	100 .242 081	160 .780 020		40 .426 828	100 .869 030	160 .997 776	
.7500	60	41 .018 948	101 .248 649	161 .790 813		41 .436 608	101 .873 573	161 .998 076	
.7034	66	42 .020 342	102 .255 313	162 .801 637		42 .446 324	102 .878 021	162 .998 363	
.6545	72	43 .021 802	103 .262 070	163 .812 491		43 .455 976	103 .882 374	163 .998 620	
.6039	78	44 .023 328	104 .268 923	164 .823 373		44 .465 561	104 .886 633	164 .998 849	
.5523	84	45 .024 921	105 .275 870	165 .834 282		45 .475 079	105 .890 797	165 .999 051	
.5000	90	46 .026 582	106 .282 910	166 .845 216		46 .484 529	106 .894 868	166 .999 228	
.4477	96	47 .028 314	107 .290 043	167 .856 174		47 .493 908	107 .898 846	167 .999 382	
.3960	102	48 .030 116	108 .297 269	168 .867 153		48 .503 217	108 .902 731	168 .999 514	
.3455	108	49 .031 991	109 .304 588	169 .878 152		49 .512 454	109 .906 524	169 .999 625	
.2966	114	50 .033 938	110 .311 998	170 .889 170		50 .521 617	110 .910 225	170 .999 718	
.2500	120	51 .035 960	111 .319 499	171 .900 205		51 .530 707	111 .913 835	171 .999 795	
.2061	126	52 .038 057	112 .327 090	172 .911 255		52 .539 721	112 .917 354	172 .999 856	
.1655	132	53 .040 231	113 .334 772	173 .922 319		53 .548 658	113 .920 784	173 .999 903	
.1239	138	54 .042 482	114 .342 543	174 .933 394		54 .557 518	114 .924 124	174 .999 939	
.0955	144	55 .044 811	115 .350 402	175 .944 480		55 .566 300	115 .927 376	175 .999 965	
.0670	150	56 .047 220	116 .358 349	176 .955 574		56 .575 002	116 .930 540	176 .999 982	
.0432	156	57 .049 710	117 .366 384	177 .966 674		57 .583 624	117 .933 616	177 .999 992	
.0245	162	58 .052 280	118 .374 505	178 .977 780		58 .592 164	118 .936 606	178 .999 998	
.0110	168	59 .054 933	119 .382 711	179 .988 889		59 .600 623	119 .939 511	179 .000 000	
.0028	174	60 .057 669	120 .391 002	180 1.000 000		60 .608 998	120 .942 331	180 1.000 000	
Deceleration									

$C_A = 4.0479 \frac{1+b}{2}$

$C_D = 4.0479 \frac{1+b}{2b}$

$C_V = 1.8401$

$b = 0.25$

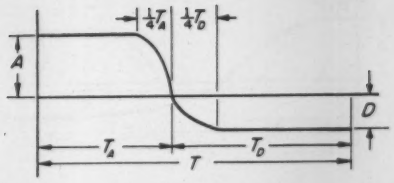


Table 6—Unity-Displacement Modified-Trapezoid, Type II

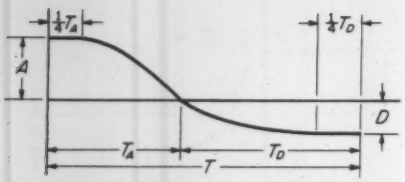
V/V_{max}

Acceleration		Acceleration				Deceleration			
0	.0000	0	.000 000			0	.000 000		
6	.0367	1	.000 031	61	.116 222	121	.457 297	1	.010 222
12	.0733	2	.000 125	62	.120 063	122	.464 887	2	.020 443
18	.1100	3	.000 281	63	.123 968	123	.472 539	3	.030 659
24	.1467	4	.000 500	64	.127 934	124	.480 254	4	.040 868
30	.1833	5	.000 781	65	.131 964	125	.488 031	5	.051 069
36	.2200	6	.001 124	66	.136 055	126	.495 871	6	.061 258
42	.2567	7	.001 530	67	.140 209	127	.503 773	7	.071 435
48	.2933	8	.001 999	68	.144 426	128	.511 738	8	.081 597
54	.3300	9	.002 530	69	.148 705	129	.519 765	9	.091 741
60	.3667	10	.003 123	70	.153 047	130	.527 854	10	.101 866
66	.4033	11	.003 779	71	.157 451	131	.536 006	11	.111 970
72	.4400	12	.004 498	72	.161 917	132	.544 221	12	.122 051
78	.4766	13	.005 279	73	.166 446	133	.552 498	13	.132 106
84	.5133	14	.006 122	74	.171 037	134	.560 838	14	.142 133
90	.5500	15	.007 028	75	.175 691	135	.569 239	15	.152 132
96	.5866	16	.007 996	76	.180 408	136	.577 704	16	.162 099
102	.6233	17	.009 027	77	.185 186	137	.586 231	17	.172 033
108	.6600	18	.010 120	78	.190 028	138	.594 820	18	.181 932
114	.6966	19	.011 275	79	.194 931	139	.603 471	19	.191 794
120	.7333	20	.012 494	80	.199 898	140	.612 184	20	.201 618
126	.7700	21	.013 774	81	.204 926	141	.620 959	21	.211 401
132	.8067	22	.015 117	82	.210 017	142	.629 794	22	.221 143
138	.8432	23	.016 523	83	.215 171	143	.638 691	23	.230 842
144	.8790	24	.017 991	84	.220 387	144	.647 647	24	.240 496
150	.9124	25	.019 521	85	.225 666	145	.656 663	25	.250 103
156	.9421	26	.021 114	86	.231 007	146	.665 737	26	.259 662
162	.9665	27	.022 770	87	.236 410	147	.674 870	27	.269 172
168	.9848	28	.024 487	88	.241 876	148	.684 059	28	.278 632
174	.9962	29	.026 268	89	.247 404	149	.693 305	29	.288 040
180	1.0000	30	.028 111	90	.252 995	150	.702 606	30	.297 394
1.0000	0	31	.030 016	91	.258 649	151	.711 960	31	.306 695
.9962	6	32	.031 984	92	.264 364	152	.721 368	32	.315 941
.9848	12	33	.034 014	93	.270 143	153	.730 828	33	.325 130
.9665	18	34	.036 106	94	.275 984	154	.740 338	34	.334 263
.9421	24	35	.038 262	95	.281 887	155	.749 897	35	.343 337
.9124	30	36	.040 479	96	.287 852	156	.759 504	36	.352 353
.8790	36	37	.042 759	97	.293 881	157	.769 158	37	.361 309
.8432	42	38	.045 102	98	.299 971	158	.778 857	38	.370 206
.8067	48	39	.047 507	99	.306 124	159	.788 599	39	.379 041
.7700	54	40	.049 974	100	.312 340	160	.798 382	40	.387 816
.7333	60	41	.052 504	101	.318 618	161	.808 206	41	.396 529
.6966	66	42	.055 097	102	.324 958	162	.818 068	42	.405 180
.6600	72	43	.057 752	103	.331 361	163	.827 967	43	.413 769
.6233	78	44	.060 469	104	.337 827	164	.837 901	44	.422 296
.5866	84	45	.063 249	105	.344 355	165	.847 868	45	.430 761
.5500	90	46	.066 091	106	.350 945	166	.857 867	46	.439 162
.5133	96	47	.068 996	107	.357 598	167	.867 894	47	.447 502
.4766	102	48	.071 963	108	.364 313	168	.877 949	48	.455 779
.4400	108	49	.074 993	109	.371 091	169	.888 030	49	.463 994
.4033	114	50	.078 085	110	.377 931	170	.898 134	50	.472 146
.3667	120	51	.081 240	111	.384 834	171	.908 259	51	.480 235
.3300	126	52	.084 457	112	.391 799	172	.918 403	52	.488 262
.2933	132	53	.087 736	113	.398 827	173	.928 565	53	.496 227
.2567	138	54	.091 078	114	.405 917	174	.938 742	54	.504 129
.2200	144	55	.094 483	115	.413 070	175	.948 931	55	.511 969
.1833	150	56	.097 950	116	.420 285	176	.959 132	56	.519 746
.1467	156	57	.101 479	117	.427 562	177	.969 341	57	.527 461
.1100	162	58	.105 071	118	.434 902	178	.979 557	58	.535 113
.0733	168	59	.108 726	119	.442 305	179	.989 778	59	.542 703
.0367	174	60	.112 442	120	.449 769	180	1.000 000	60	.550 231

Deceleration			
61	.557 695	121	.891 274
62	.565 098	122	.894 929
63	.572 438	123	.898 521
64	.579 715	124	.902 050
65	.586 930	125	.905 517
66	.594 082	126	.908 922
67	.601 172	127	.912 264
68	.608 201	128	.915 543
69	.615 166	129	.918 760
70	.622 069	130	.921 915
71	.628 909	131	.925 007
72	.635 687	132	.928 037
73	.642 402	133	.931 004
74	.649 055	134	.933 909
75	.655 645	135	.936 751
76	.662 173	136	.939 531
77	.668 639	137	.942 248
78	.675 042	138	.944 903
79	.681 382	139	.947 496
80	.687 660	140	.950 026
81	.693 876	141	.952 493
82	.700 029	142	.954 898
83	.706 119	143	.957 241
84	.712 148	144	.959 521
85	.718 113	145	.961 738
86	.724 016	146	.963 894
87	.729 857	147	.965 986
88	.735 636	148	.968 016
89	.741 351	149	.969 984
90	.747 005	150	.971 889
91	.752 596	151	.973 732
92	.758 124	152	.975 513
93	.763 590	153	.977 230
94	.768 993	154	.978 886
95	.774 334	155	.980 479
96	.779 613	156	.982 009
97	.784 829	157	.983 477
98	.789 983	158	.984 883
99	.795 074	159	.986 226
100	.800 102	160	.987 506
101	.805 069	161	.988 725
102	.809 972	162	.989 880
103	.814 814	163	.990 973
104	.819 592	164	.992 004
105	.824 309	165	.992 972
106	.828 963	166	.993 878
107	.833 554	167	.994 721
108	.838 083	168	.995 502
109	.842 549	169	.996 221
110	.846 953	170	.996 877
111	.851 295	171	.997 470
112	.855 574	172	.998 001
113	.859 791	173	.998 470
114	.863 945	174	.998 876
115	.868 036	175	.999 219
116	.872 066	176	.999 500
117	.876 032	177	.999 719
118	.879 937	178	.999 875
119	.883 778	179	.999 969
120	.887 558	180	1.000 000

Deceleration

DATA SHEET



$C_A = 4.4770 \frac{1+P}{2}$

$C_D = 4.4770 \frac{1+P}{2P}$

$C_V = 1.6284$

$c = 0.25$

Table 7—Unity-Displacement Modified-Sine, Type II

V/V_{max}

Acceleration		Acceleration				Deceleration			
0 .0000		0 .000 000				0 .000 000			
6 .0458		1 .000 034	61 .128 517	121 .493 107		1 .009 047	61 .522 208	121 .879 764	
12 .0916		2 .000 138	62 .132 759	122 .500 830		2 .018 093	62 .529 799	122 .883 802	
18 .1375		3 .000 311	63 .137 069	123 .508 597		3 .027 137	63 .537 343	123 .887 771	
24 .1833		4 .000 553	64 .141 446	124 .516 406		4 .036 179	64 .544 842	124 .891 672	
30 .2291		5 .000 864	65 .145 891	125 .524 258		5 .045 218	65 .552 294	125 .895 505	
36 .2749		6 .001 244	66 .150 403	126 .532 150		6 .054 253	66 .559 698	126 .899 269	
42 .3208		7 .001 693	67 .154 982	127 .540 083		7 .063 283	67 .567 055	127 .902 964	
48 .3666		8 .002 211	68 .159 628	128 .548 056		8 .072 307	68 .574 362	128 .906 591	
54 .4123		9 .002 798	69 .164 340	129 .556 069		9 .081 325	69 .581 621	129 .910 149	
60 .4576		10 .003 454	70 .169 119	130 .564 120		10 .090 336	70 .588 830	130 .913 638	
66 .5024		11 .004 180	71 .173 964	131 .572 209		11 .099 339	71 .595 989	131 .917 058	
72 .5465		12 .004 974	72 .178 876	132 .580 335		12 .108 332	72 .603 096	132 .920 408	
78 .5895		13 .005 838	73 .183 852	133 .588 498		13 .117 316	73 .610 153	133 .923 690	
84 .6314		14 .006 771	74 .188 894	134 .596 697		14 .126 290	74 .617 158	134 .926 903	
90 .6718		15 .007 773	75 .194 002	135 .604 931		15 .135 253	75 .624 110	135 .930 046	
96 .7107		16 .008 843	76 .199 174	136 .613 199		16 .144 203	76 .631 009	136 .933 121	
102 .7477		17 .009 983	77 .204 411	137 .621 502		17 .153 141	77 .637 855	137 .936 126	
108 .7828		18 .011 193	78 .209 713	138 .629 837		18 .162 065	78 .644 647	138 .939 062	
114 .8157		19 .012 471	79 .215 078	139 .638 205		19 .170 975	79 .651 384	139 .941 930	
120 .8464		20 .013 818	80 .220 507	140 .646 605		20 .179 870	80 .658 067	140 .944 728	
126 .8746		21 .015 234	81 .226 000	141 .655 036		21 .188 749	81 .664 694	141 .947 457	
132 .9003		22 .016 720	82 .231 555	142 .663 496		22 .197 611	82 .671 265	142 .950 117	
138 .9231		23 .018 274	83 .237 174	143 .671 987		23 .206 456	83 .677 780	143 .952 708	
144 .9432		24 .019 898	84 .242 855	144 .680 507		24 .215 282	84 .684 238	144 .955 230	
150 .9604		25 .021 591	85 .248 598	145 .689 054		25 .224 089	85 .690 639	145 .957 682	
156 .9745		26 .023 352	86 .254 403	146 .697 629		26 .232 877	86 .696 982	146 .960 066	
162 .9856		27 .025 183	87 .260 269	147 .706 231		27 .241 643	87 .703 267	147 .962 380	
168 .9936		28 .027 083	88 .266 196	148 .714 858		28 .250 389	88 .709 493	148 .964 626	
174 .9984		29 .029 052	89 .272 184	149 .723 510		29 .259 112	89 .715 660	149 .966 802	
180 1.0000		30 .031 091	90 .278 232	150 .732 187		30 .267 813	90 .721 768	150 .968 909	
1.0000	0	31 .033 198	91 .284 340	151 .740 888		31 .276 490	91 .727 816	151 .970 948	
.9984	6	32 .035 374	92 .290 507	152 .749 611		32 .285 142	92 .733 804	152 .972 917	
.9936	12	33 .037 620	93 .296 733	153 .758 357		33 .293 769	93 .739 731	153 .974 817	
.9856	18	34 .039 934	94 .303 018	154 .767 123		34 .302 371	94 .745 597	154 .976 648	
.9745	24	35 .042 318	95 .309 361	155 .775 911		35 .310 946	95 .751 402	155 .978 409	
.9604	30	36 .044 770	96 .315 762	156 .784 718		36 .319 493	96 .757 145	156 .980 102	
.9432	36	37 .047 292	97 .322 220	157 .793 544		37 .328 013	97 .762 826	157 .981 726	
.9231	42	38 .049 883	98 .328 735	158 .802 389		38 .336 504	98 .768 445	158 .983 280	
.9003	48	39 .052 543	99 .335 306	159 .811 251		39 .344 964	99 .774 000	159 .984 766	
.8746	54	40 .055 272	100 .341 933	160 .820 130		40 .353 395	100 .779 493	160 .986 182	
.8464	60	41 .058 070	101 .348 616	161 .829 025		41 .361 795	101 .784 922	161 .987 529	
.8157	66	42 .060 938	102 .355 353	162 .837 935		42 .370 163	102 .790 287	162 .988 807	
.7828	72	43 .063 874	103 .362 145	163 .846 859		43 .378 498	103 .795 589	163 .990 017	
.7477	78	44 .066 879	104 .368 991	164 .855 797		44 .386 801	104 .800 826	164 .991 157	
.7107	84	45 .069 954	105 .375 890	165 .864 747		45 .395 069	105 .805 998	165 .992 227	
.6718	90	46 .073 097	106 .382 842	166 .873 710		46 .403 303	106 .811 106	166 .993 229	
.6314	96	47 .076 310	107 .389 847	167 .882 684		47 .411 502	107 .816 148	167 .994 162	
.5895	102	48 .079 592	108 .396 904	168 .891 668		48 .419 665	108 .821 124	168 .995 526	
.5465	108	49 .082 942	109 .404 011	169 .900 661		49 .427 791	109 .826 036	169 .995 820	
.5024	114	50 .086 362	110 .411 170	170 .909 664		50 .435 880	110 .830 881	170 .996 546	
.4576	120	51 .089 851	111 .418 379	171 .918 675		51 .443 931	111 .835 660	171 .997 202	
.4123	126	52 .093 409	112 .425 638	172 .927 693		52 .451 944	112 .840 372	172 .997 789	
.3666	132	53 .097 036	113 .432 945	173 .936 717		53 .459 917	113 .845 018	173 .998 307	
.3208	138	54 .100 731	114 .440 302	174 .945 747		54 .467 850	114 .849 597	174 .998 756	
.2749	144	55 .104 495	115 .447 706	175 .954 782		55 .475 742	115 .854 109	175 .999 136	
.2291	150	56 .108 328	116 .455 158	176 .963 821		56 .483 594	116 .858 554	176 .999 447	
.1833	156	57 .112 229	117 .462 657	177 .972 863		57 .491 403	117 .862 931	177 .999 689	
.1375	162	58 .116 198	118 .470 201	178 .981 907		58 .499 170	118 .867 241	178 .999 862	
.0916	168	59 .120 236	119 .477 792	179 .990 953		59 .506 893	119 .871 483	179 .999 966	
.0458	174	60 .124 343	120 .485 427	180 1.000 000		60 .514 573	120 .875 657	180 1.000 000	
.0000	180								

Deceleration

$C_A = 4.1988 \frac{1+P}{2}$

$C_D = 4.1988 \frac{1+P}{2P}$

$C_V = 1.7180$

$c = 0.50$

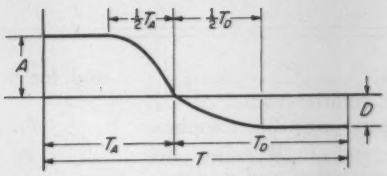


Table 8—Unity-Displacement Sine, Type II

Acceleration V/V_{max}		Acceleration						Deceleration					
0	.0000	0	.000 000					0	.000 000				
6	.0407	1	.000 032	61	.120 555	121	.473 594	1	.009 544	61	.541 781	121	.887 221
12	.0815	2	.000 130	62	.124 540	122	.481 386	2	.019 087	62	.549 385	122	.891 011
18	.1222	3	.000 292	63	.128 590	123	.489 192	3	.028 628	63	.556 931	123	.894 737
24	.1629	4	.000 518	64	.132 704	124	.497 073	4	.038 165	64	.564 419	124	.898 398
30	.2037	5	.000 810	65	.136 884	125	.505 008	5	.047 698	65	.571 849	125	.901 995
36	.2444	6	.001 166	66	.141 128	126	.512 995	6	.057 225	66	.579 220	126	.905 526
42	.2851	7	.001 588	67	.145 437	127	.521 036	7	.066 746	67	.586 532	127	.908 993
48	.3259	8	.002 073	68	.149 811	128	.529 127	8	.076 258	68	.593 785	128	.912 394
54	.3666	9	.002 624	69	.154 249	129	.537 270	9	.085 762	69	.600 977	129	.915 731
60	.4078	10	.003 240	70	.158 753	130	.545 463	10	.095 255	70	.608 109	130	.919 004
66	.4481	11	.003 920	71	.163 321	131	.553 706	11	.104 737	71	.615 180	131	.922 211
72	.4888	12	.004 665	72	.167 954	132	.561 998	12	.114 207	72	.622 190	132	.925 354
78	.5296	13	.005 475	73	.172 652	133	.570 338	13	.123 663	73	.629 138	133	.928 432
84	.5703	14	.006 350	74	.177 414	134	.578 725	14	.133 105	74	.636 024	134	.931 445
90	.6110	15	.007 290	75	.182 242	135	.587 159	15	.142 531	75	.642 848	135	.934 393
96	.6517	16	.008 294	76	.187 134	136	.595 639	16	.151 940	76	.649 609	136	.937 276
102	.6919	17	.009 363	77	.192 091	137	.604 163	17	.161 332	77	.656 308	137	.940 095
108	.7365	18	.010 497	78	.197 113	138	.612 732	18	.170 704	78	.662 943	138	.942 849
114	.7692	19	.011 696	79	.202 199	139	.621 345	19	.180 057	79	.669 515	139	.945 538
120	.8055	20	.012 959	80	.207 350	140	.629 999	20	.189 388	80	.676 023	140	.948 162
126	.8397	21	.014 288	81	.212 567	141	.638 696	21	.198 697	81	.682 468	141	.950 722
132	.8713	22	.015 681	82	.217 848	142	.647 433	22	.207 983	82	.688 848	142	.953 217
138	.9000	23	.017 139	83	.223 193	143	.656 210	23	.217 245	83	.695 164	143	.955 646
144	.9257	24	.018 662	84	.228 604	144	.665 026	24	.226 481	84	.701 416	144	.958 012
150	.9479	25	.020 249	85	.234 079	145	.673 880	25	.235 691	85	.707 604	145	.960 312
156	.9663	26	.021 901	86	.239 619	146	.682 772	26	.244 874	86	.713 727	146	.962 547
162	.9810	27	.023 619	87	.245 224	147	.691 695	27	.254 028	87	.719 785	147	.964 718
168	.9915	28	.025 400	88	.250 894	148	.700 662	28	.263 152	88	.725 779	148	.966 824
174	.9979	29	.027 247	89	.256 629	149	.709 659	29	.272 247	89	.731 708	149	.968 865
180	1.0000	30	.029 159	90	.262 428	150	.718 690	30	.281 310	90	.737 572	150	.970 841
1.0000	0	31	.031 135	91	.268 292	151	.727 753	31	.290 341	91	.743 371	151	.972 753
.9979	6	32	.033 176	92	.274 221	152	.736 847	32	.299 338	92	.749 106	152	.974 600
.9915	12	33	.035 282	93	.280 215	153	.745 972	33	.308 301	93	.754 776	153	.976 381
.9810	18	34	.037 453	94	.286 273	154	.755 126	34	.317 228	94	.760 381	154	.978 099
.9663	24	35	.039 688	95	.292 396	155	.764 309	35	.326 120	95	.765 921	155	.979 751
.9479	30	36	.041 988	96	.298 584	156	.773 519	36	.334 974	96	.771 396	156	.981 338
.9257	36	37	.044 354	97	.304 836	157	.782 755	37	.343 790	97	.776 807	157	.982 861
.9000	42	38	.046 783	98	.311 152	158	.792 017	38	.352 567	98	.782 152	158	.984 319
.8713	48	39	.049 278	99	.317 532	159	.801 303	39	.361 304	99	.787 433	159	.985 712
.8397	54	40	.051 838	100	.323 977	160	.810 612	40	.370 001	100	.792 650	160	.987 041
.8055	60	41	.054 462	101	.330 485	161	.819 943	41	.378 655	101	.797 801	161	.988 304
.7692	66	42	.057 151	102	.337 057	162	.829 296	42	.387 268	102	.802 887	162	.989 503
.7365	72	43	.059 905	103	.343 692	163	.838 668	43	.395 837	103	.807 909	163	.990 637
.6919	78	44	.062 724	104	.350 391	164	.848 060	44	.404 361	104	.812 866	164	.991 706
.6517	84	45	.065 607	105	.357 152	165	.857 469	45	.412 841	105	.817 758	165	.992 710
.6110	90	46	.068 555	106	.363 976	166	.866 895	46	.421 275	106	.822 586	166	.993 650
.5703	96	47	.071 568	107	.370 862	167	.876 337	47	.429 662	107	.827 348	167	.994 525
.5296	102	48	.074 646	108	.377 810	168	.885 793	48	.438 002	108	.832 046	168	.995 335
.4888	108	49	.077 789	109	.384 820	169	.895 263	49	.446 294	109	.836 679	169	.996 080
.4481	114	50	.080 996	110	.391 891	170	.904 745	50	.454 537	110	.841 247	170	.996 760
.4078	120	51	.084 269	111	.399 023	171	.914 238	51	.462 730	111	.845 751	171	.997 376
.3666	126	52	.087 606	112	.406 215	172	.923 742	52	.470 873	112	.850 189	172	.997 927
.3259	132	53	.091 007	113	.413 468	173	.933 254	53	.478 964	113	.854 563	173	.998 412
.2851	138	54	.094 474	114	.420 780	174	.942 775	54	.487 005	114	.858 872	174	.998 834
.2444	144	55	.098 005	115	.428 151	175	.952 302	55	.494 992	115	.863 116	175	.999 190
.2037	150	56	.101 602	116	.435 581	176	.961 835	56	.502 927	116	.867 296	176	.999 482
.1629	156	57	.105 263	117	.443 069	177	.971 372	57	.510 808	117	.871 410	177	.999 708
.1222	162	58	.108 989	118	.450 615	178	.980 913	58	.518 634	118	.875 460	178	.999 870
.0815	168	59	.112 779	119	.458 219	179	.990 456	59	.526 406	119	.879 445	179	.999 965
.0407	174	60	.116 635	120	.465 878	180	1.000 000	60	.534 122	120	.883 365	180	1.000 000
Deceleration													

composites of I and II, Table 1.

Each of these shapes has definite values of C_A, C_v, and C_D. The coefficients are dimensionless, therefore independent of S and T. If values are known for s_A, s_D, and t_D, acceleration and deceleration periods can be treated separately.

Flexibility of Diagrams: Up to this point, structures of diagrams were affected only by selection of factors b and c. It was assumed that T is equally divided between the acceleration and the deceleration periods. There are occasions, however, when T_A and T_D must be changed while T is constant. For this purpose, an additional factor, P, is introduced. By definition, for curve types I and II,

$$P = \frac{T_D}{T_A} \tag{4}$$

and, for curve type III,

$$P = \frac{T_{II}}{T_I} \tag{5}$$

Since it is assumed that the cam rotates at constant speed,

$$P = \frac{\alpha_D}{\alpha_A} \tag{6}$$

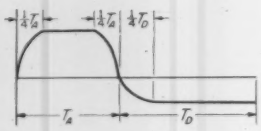
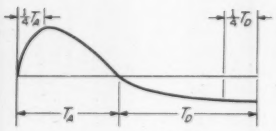
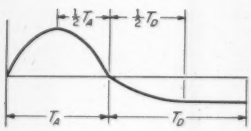
Equations 4, 5, and 6 yield:

$$t_A = \frac{T}{1 + P} \tag{7}$$

$$t_D = \frac{P}{1 + P} T \tag{8}$$

Table 9—Characteristics of Combined Diagrams, Type III

Stroke starts from a dwell, and is reversed without a dwell

Shape			
Type	Modified Trapezoid	Modified Sine	Sine
Factor Values	$b = 1/4$	$c = 1/4$	$b = c = 1/2$
Source of Unity Tables for s and v during:			
A-Period. Use I_A and $I_{v\,acc}$ in.:	Table 3	Table 4	Table 5
D-Period. Use II_D and $II_{v\,dec}$ in:	Table 6	Table 7	Table 8
Equations:			
$S_A =$	$\left(\frac{1}{1 + 1.0869\,P}\right) S$	$\left(\frac{1}{1 + 1.0805\,P}\right) S$	$\left(\frac{1}{1 + 1.1642\,P}\right) S$
$S_D =$	$\left(\frac{1.0869\,P}{1 + 1.0869\,P}\right) S$	$\left(\frac{1.0805\,P}{1 + 1.0805\,P}\right) S$	$\left(\frac{1.1642\,P}{1 + 1.1642\,P}\right) S$
$C_A =$	$4.8881\left(\frac{1 + P}{2}\right)^*$	$5.5280\left(\frac{1 + P}{2}\right)^\dagger$	$6.2832\left(\frac{1 + P}{2}\right)^\S$
$C_D =$	$4.3907\left(\frac{1 + P}{2P}\right)^*$	$4.8376\left(\frac{1 + P}{2P}\right)^\dagger$	$4.8881\left(\frac{1 + P}{2P}\right)^\S$
$C_v =$	2.0000*	1.7596†	2.0000§
$\frac{C_A}{C_D} =$	$1.1110\,P$	$1.1427\,P$	$1.2854\,P$
Multiply expressions marked correspondingly above, by:	$^*\left(\frac{1 + P}{1 + 1.0869\,P}\right)$	$^\dagger\left(\frac{1 + P}{1 + 1.0805\,P}\right)$	$^\S\left(\frac{1 + P}{1 + 1.1642\,P}\right)$

$$\alpha_A = \frac{\alpha}{1+P} \tag{9}$$

$$\alpha_D = \frac{P}{1+P}\alpha \tag{10}$$

Table 2 gives the sequence of calculations leading to final cam profiles.

Displacement Tables: Actual values for displacement are obtained from Tables 3 to 8. Each of these tables has been calculated with only one value—the most frequently used—of b or c. Displacements are listed in one-degree increments for one full stroke. Maximum displacement is $S = 1$, so the tables are called "unity displacement tables." To prepare displacement tables for particular cams, values in the unity tables are multiplied by the actual stroke S for n selected and equal divisions of T, Table 2. Displacement during the acceleration and deceleration periods can be calculated separately.

Tables 3 to 8 pertain to diagram types I and II in modified-trapezoid, modified-sine, and sine shapes. The same tables can be used for diagrams type III, but correct sequence must be observed. If columns I_A and II_D are used for the advance stroke, use columns II_A and I_D, in that order, for the return stroke. Additional information for type III diagrams appears in Table 9.

For diagram types I and II,

$$P = \frac{t_D}{t_A} = \frac{\alpha_D}{\alpha_A} = \frac{s_D}{s_A} \tag{11}$$

For diagram types III,

$$P = \frac{t_D}{t_A} = \frac{\alpha_D}{\alpha_A} \neq \frac{s_D}{s_A} \tag{12}$$

If values of the factors b or c are to be used, other than the values used for the tables herewith, new unity tables must be made.

Velocity Tables: If it is important that certain speeds be gained after certain time periods, velocity diagrams are useful. Tables in this article have 30 increments for period T_A and the same number for period T_D.

The tables give values of

$$\frac{v}{\frac{S}{T}C_v} = \frac{v\alpha}{360SNC_v} \tag{13}$$

To calculate design values for an actual velocity chart, multiply figures from the velocity tables by

$$\frac{S}{T}C_v = \frac{360SNC_v}{\alpha} \tag{14}$$

Velocity tables are given only for diagrams I and II. For diagrams III, combine the proper sections of I and II. Note that velocity coefficients C_v are independent of P for diagrams I and II, but dependent on P in diagrams III.

Example 1: A barrel cam must rotate a follower assembly which has the form of a disc with a number of rollers on its periphery. The rollers engage the cam in a way that the disc always turns in one

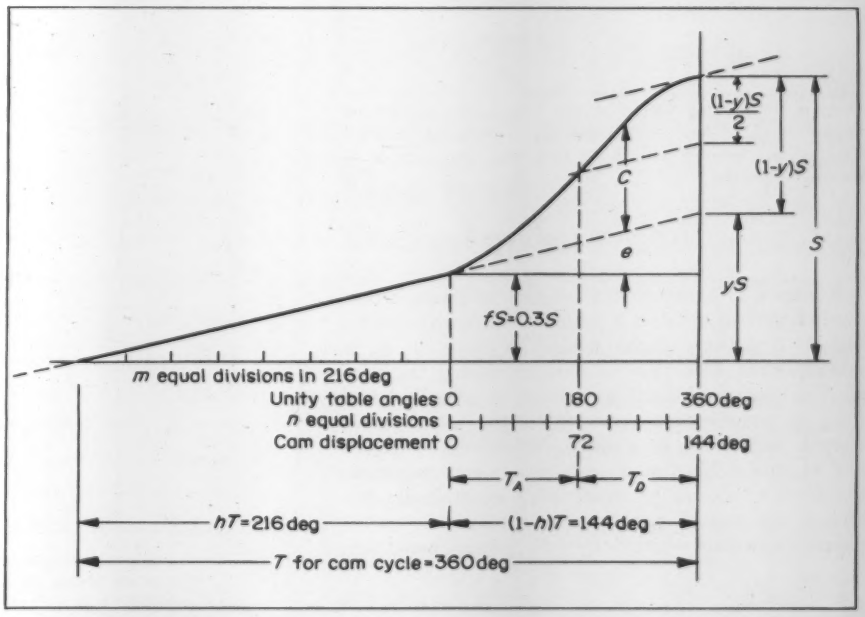


Fig. 2 — Displacement diagram for a barrel cam which drives in one direction, partly at constant speed, partly at varying speed.

direction, and without stops. During one revolution of the cam, the follower alternates between constant speed and varying speed. A part f of the stroke is produced at constant velocity, such that $fS = 0.3\ S$, or $f = 0.3$. The period of constant velocity is $hT = 0.6\ T$, or $h = 0.6$. The remaining stroke $(1 - f)S$ is made during the time $(1 - h)T$, with lowest possible acceleration and deceleration. Velocity at the end of a stroke must equal the constant velocity at the beginning of the next cycle. In Fig. 2, which illustrates this example, time T is expressed as cam rotation from 0 to 360 deg. As Fig. 2 shows, displacement during the period of varying velocity has two parts: Displacement $FS + e$ due to constant velocity, and displacement C due to varying velocity. The procedure is:

1. During time hT, displacement is fS. Then, displacement for full time T is $yS = (f/h)S$, or $y = f/h = 0.3/0.6 = 0.5$. Displacement during the part of the stroke which has varying velocity is $(1 - y)S = 0.5\ S$, and displacement during acceleration and deceleration is $s_A = s_D = \frac{1}{2}(1 - y)S$

2. Multply these displacements by figures from type-I unity tables to obtain values for C. Displacement during the period of varying velocity is produced while the cam rotates 144 deg. Therefore, each selected division of the unity tables corresponds to $144/n$ deg on the cam, Fig. 2.

3. For each division of $144/n$ deg, determine the value a. This value changes from 0 to $(y - f)S = (0.5 - 0.3)S = 0.2\ S$. Therefore, a increases by increments of $0.2\ S/n$ per division.

4. The final table of displacements during the period of varying velocity is made by adding $0.3\ S$ to $(e + c)$.

5. To calculate displacements during the constant-velocity period, divide the period of constant velocity, which is 216 deg of cam rotation, into m equal parts. Since total displacement during the constant-velocity period is $0.3\ S$, increase of displacement during each part is $(0.3/m)S$.

6. Maximum acceleration during the period of varying velocity is

$$a_{max} = (C_a)[(1 - y)S]\left(\frac{360\ N}{a}\right)^2$$

where α = working period of the cam during accelerated motion $= (1 - h)T = 144$ deg, $C_A = 4.89$ for modified trapezoid acceleration with $b = 0.25$, and the units of N are rps. Therefore,

$$a_{max} = (4.89)(0.5S)\left(\frac{360\ N}{144}\right)^2$$

Example 2: A required movement is dwell-stroke-dwell type and includes a period of uniform velocity, Fig. 3. A portion of the stroke, $kS = s_1 + s_2$, is accomplished with varying velocity during the time t_v. The period of uniform velocity t_u should be as long as possible, and velocity in the same period should be as low as possible. Velocity is 0 at the end of stroke. Maximum acceleration and maximum deceleration should be equal. This example demonstrates the use of velocity and acceleration coefficients. Equations which satisfy the requirements are:

$$t_1 + t_2 = t_v \tag{15}$$

$$s_1 + s_2 = kS \tag{16}$$

$$t_3 + t_4 = t_u = T - t_v \tag{17}$$

$$s_3 + s_4 = (1 - k)S \tag{18}$$

Values of t_v, T, S, and k are given.

Equalizing velocities, periods 1 *and* 2: The velocity at the end of period 1 should equal the velocity at the beginning of period 2. At the end of period 2 and throughout period 3, velocity is constant, v_c.

When an accelerated movement starts from or ends with a certain velocity, displacement is created by two factors: Constant velocity and varying velocity. Therefore,

$$s_2 = v_c t_2 + s_{2D}$$

where s_{2D} is displacement due to varying velocity, Fig. 3*a*. Expressions introduced from basic equations yield

$$s_{2D} = (kS - s_1) - v_c(t_v - t_1)$$

For modified-trapezoid acceleration with $b = 0.25$, the maximum velocity coefficient $C_v = 2$. That is, the maximum velocity is twice the average velocity.

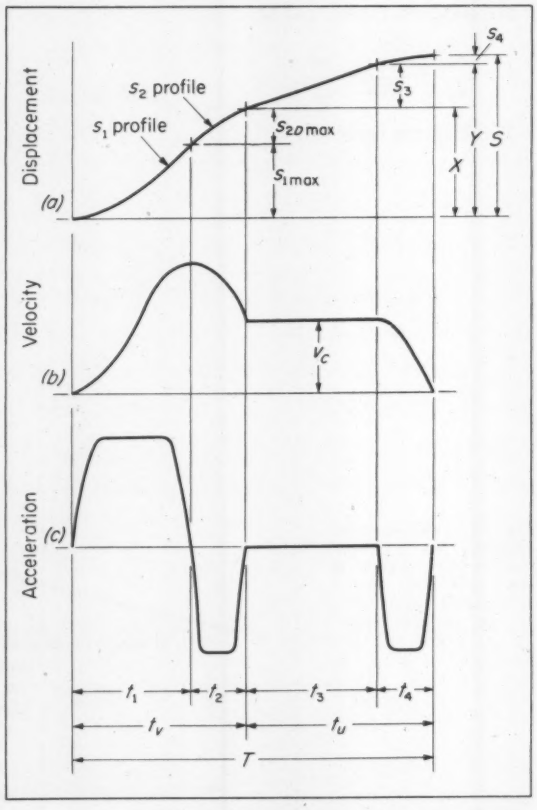


Fig. 3—Development of a displacement diagram having equalized velocities and accelerations at junctions of time periods.

Therefore, maximum velocity at the end of period 1 is

$$C_v \frac{s_1}{t_1} = 2\frac{s_1}{t_1}$$

The same velocity, expressed in terms of period 2, is

$$v_c + C_v \frac{s_{2D}}{t_2} = 2\frac{kS - s_1}{t_v - t_1} - v_c$$

Equalizing velocities, periods 3 *and* 4: At the end of period 3, velocity is v_c. The same velocity, expressed in terms of period 4, is

$$v_c = C_v \frac{s_4}{t_4} = 2\frac{(1-k)(S - s_3)}{t_u - t_3}$$

Since $s_3 = v_c t_3$, the constant velocity, expressed in terms of period 3, is

$$v_c = 2\frac{(1-k)S - v_c t_3}{t_u - t_3} = \frac{2(1-k)S}{t_u + t_3}$$

Equalizing accelerations and decelerations: Equations for maximum acceleration in period 1 and for maximum decelerations in periods 2 and 4 are mutually equivalent. In all periods with varying velocities, a modified-trapezoid acceleration is used, with $b = 0.25$. For all three periods $C_A = 4.89$. Expressions are:

Maximum acceleration, period 1,

$$C_A \frac{s_1}{{t_1}^2}$$

Maximum deceleration, period 2,

$$C_A \frac{s_{2D}}{{t_2}^2} = C_A \left[\frac{kS - s_1}{(t_v - t_1)^2} - \frac{v_c}{t_v - t_1} \right]$$

Maximum deceleration, period 4,

$$C_A \frac{s_4}{{t_4}^2} = C_A \frac{(1-k)S - s_3}{(t_u - t_3)^2} = C_A \frac{v_c}{2(t_u - t_3)}$$

For use in these equations, the expression for t_1 is

$$t_1 = \frac{k t_u + (2k-1)t_v}{3k-1} \pm \left[\left(\frac{k t_u + (2k-1)t_v}{3k-1} \right)^2 - \frac{k t_u t_v + (2k-1)(t_v^2/2)}{3k-1} \right]^{1/2}$$

Equations for displacements in periods are

$$s_1 = \frac{v_c {t_1}^2}{2(2t_1 - t_v)}$$

$s_2 = kS - s_1$ from Equation 16

$s_{2D} = s_2 - v_c t_2$ from Equation 19

$s_3 = v_c t_3$ from Fig. 3*b*

$s_4 = (1-k)S - s_3$ from Equation 18

To obtain the final displacement curve, Fig. 3*a*:

1. For period 1, select values at a number of equal divisions from 0 to 180 deg in Table 3, Column I_A. Multiply these values by s_1. Note the displacement obtained with s_{1max}
2. For period 2, proceed the same way with values of s_{2D}, but use Column I_D. Be sure that members of selections in I_A and I_D are the same. Add displacements $s_{1max} + s_{2D} + v_c t_2/g$, where g = Number of divisions used for s_{2D}.
3. Displacement at the end of the period 2 is designated *X*, Fig. 3*a*.
4. For period 3, increase *X* by increments of $v_c t_3/h$, where h = Number of divisions for period 3.
5. At the end of period 3, total displacement is *Y*.
6. For period 4, multiply s_4 by Column I_D, Table 3, and add *Y* to each.

Solution of this example looks complicated, but in practice, many symbols such as t_u, t_v, *S*, and *k* are replaced by low numbers which simplify calculations.

ACKNOWLEDGEMENT

This article is based on a paper presented by the author at the Fifth Conference on Mechanisms cosponsored by Purdue University and MACHINE DESIGN, October 13-14, 1958.

Conference Transactions

Transactions of the Fifth Conference on Mechanisms (239 pages), containing the 19 papers presented, are available at $3.00 each from Reader Service Dept., MACHINE DESIGN, Penton Bldg., Cleveland 13, Ohio.

Tips and Techniques

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By trigonometry, ¾ in. taper = 3 deg 34 min 44 sec.
—F. MURRAY, *Chicago, Ill.*

Magnetic-Type Mechanical Seals

ABBOTT W. LIGHTER
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AN effective magnetic-type mechanical seal has been developed which meets the need for simplicity of installation and small space requirements. Initial operational results of these seals with most fluids are good. While the seal is not offered as a cure-all in its present stage of development, it does meet a specific need in many applications and with further development offers promise for use in other services.

Basically, a mechanical seal achieves its primary seal between two relatively rotating, optically flat surfaces which are generally in a plane perpendicular to the axis of rotation. The two sealing elements which contain the primary-seal surfaces then must be sealed in some manner, one to the rotary shaft and one to the stationary housing.

A number of mechanical seals are available which provide effective and virtually leakless service over a wide range of operating conditions. Design improvements must resolve two more major problems: Large space required to physically house the seal, and the involved and often critical installation of the seals. Also, to prevent poor operation and premature failure, installation must be fool-proof. In existing seals, the faces are held in sealing contact, either completely or in part, by compression springs. These springs require a collar or stop against which to act. The positioning of this stop is critical as the spring compression must load the seal faces without overloading.

When the basic idea of utilizing magnetic attraction between the rotary and stationary seal members was conceived, it was theorized that if a nonmechanical pull could replace the mechanical push of the springs, the problem of critical installation and adjustment would be eliminated. There also appeared to be a possibility of drastically reducing the seal length.

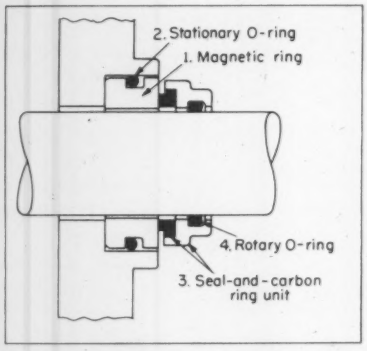

Fig. 1—Magnetism provides the closing force in this sealed drive. Parts 1 and 2 are stationary. Parts 3 and 4 rotate.

Several permanent-magnetic materials were evaluated prior to arriving at the presently used Alnico 5. This material, in the form of a vacuum-cast ring, provides an excellent sealing surface and displays the best magnetic qualities of the materials evaluated. The extreme hardness of this material along with its particular grain structure provides a compatible seal surface for successful operation against many grades of variously impregnated carbon rings.

Now that a suitable magnetic material and a set of compatible faces had been developed, the remaining problem is the method of driving the rotary unit with the rotating shaft. The extremely small rotary mass required, due to the elimination of springs and spring devices, suggests the use of O-rings which, by friction, provide the necessary driving force. An O-ring is used between the rotary seal ring and shaft as a secondary seal. If this ring can serve a twofold purpose, over-all seal size can be reduced further.

Tests prove that only in rare cases, in which the product handled hardens or becomes extremely gummy, does this O-ring fail to drive the rotary ring. These rare cases are generally excluded from mechanical seal applications because of the possibility of seal-face damage. For all practical purposes, the O-ring drive is completely effective.

The O-ring drive coupled with the use of magnetism as the closing force in the seal provides a very

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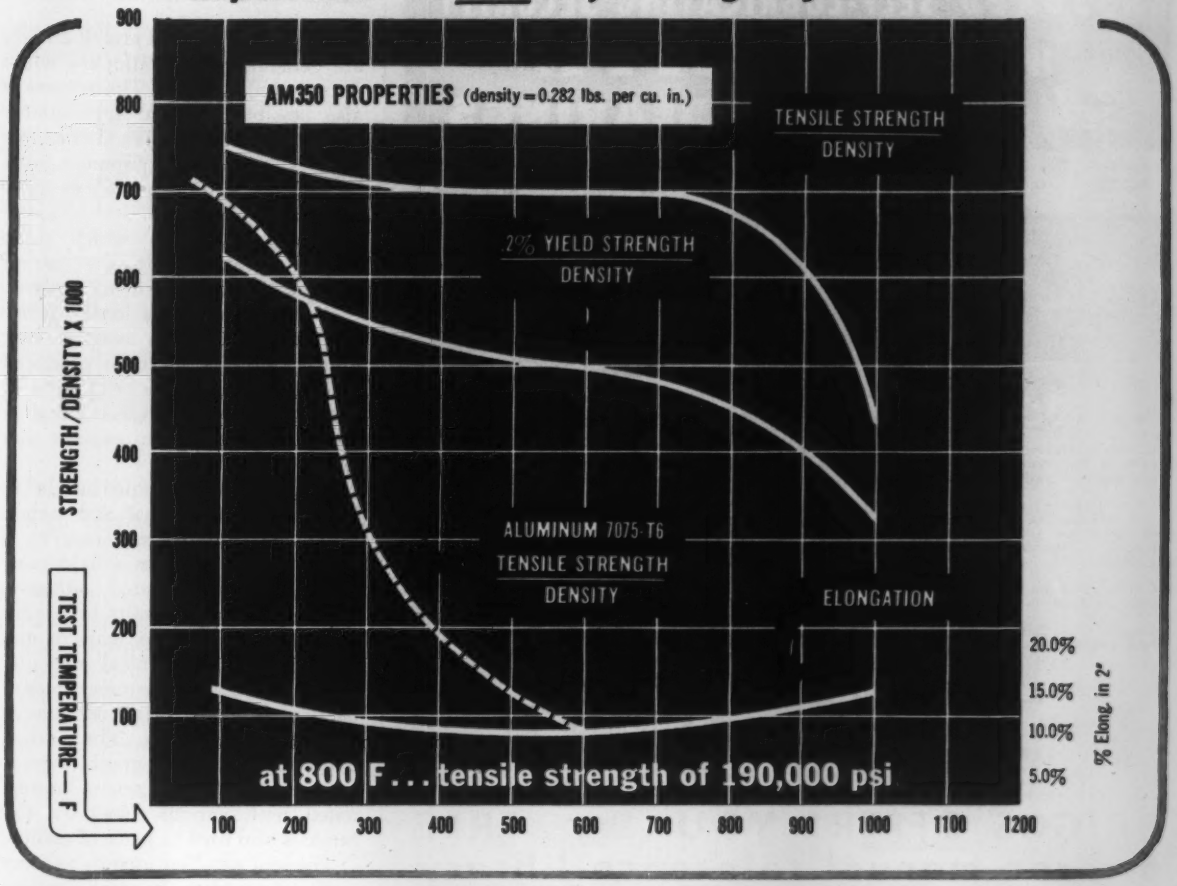

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For further information, see your A-L sales engineer or write for the booklet "Engineering Properties, AM350 and AM355." *Allegheny Ludlum Steel Corporation, Oliver Building, Pittsburgh 22, Pa.* Address Dept. MD-22.

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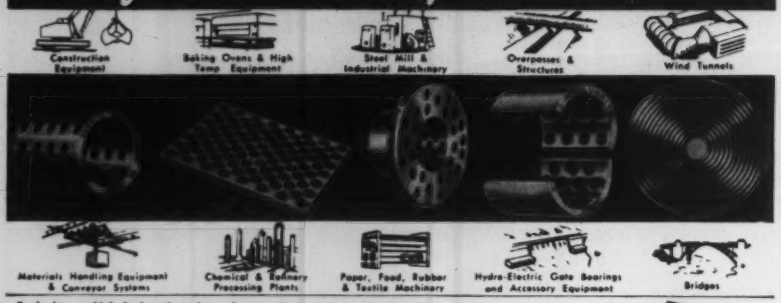
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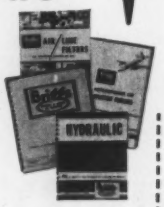

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simple seal, Fig. 1. Parts 1 and 2, are generally held stationary while parts 3 and 4 rotate. The reverse is also possible in some applications.

A gland or other method of adapting the seal to the equipment must be utilized with this seal as with all mechanical seals.

One consideration which must not be overlooked in the use of magnetic-type mechanical seals is that the gland or stationary member into which the magnet ring unit is inserted must be produced of a nonmagnetic material such as brass, 300-series stainless steel, or special high corrosion-resistant materials.

It should also be noted in the illustration that the seal and carbon is bonded into the seal case by a process which involves a light press fit plus an oven-cured adhesive. This combination results in a joint that is impervious to leakage and has excellent mechanical strength.

The O-rings are elastomers manufactured from the many varieties of commercial materials. The carbon is normally a carbon-graphite grade or a composition of carbon impregnated with various materials. Ceramic is also used in place of carbon.

The seal was first used in military applications where its small size and weight were of great value. Successful military uses of the seal were generally on equipment of a very precise nature and only for the containment of lubricating fluids.

Nonmilitary applications present many new problems. Industrial applications call for use of the seal with all types of fluids and under a wide range of conditions. The major problem presented by these applications is corrosion, in that the magnet has a high percentage of iron (approximately 51 per cent). Additional test work indicates that a heavy rhodium plate renders the magnet virtually impervious to attack by corrosives as well as providing a good running surface.

The seal in this plated form is reported satisfactory. However, some difficulty has been encountered in the handling of light, nonlubricating hydrocarbons, particularly at high pressures. The nonlubricating fluids require that the carbon be able to withstand excessive wear. The carbon protrusion is limited as

this is the air gap through which the magnetic field acts. The strength of the magnetic pull varies inversely with the square of the gap size and thus limits the carbon protrusion. Tests are currently being conducted in an effort to overcome this problem, and initial results indicate that the problem can be solved.

ASME paper 59-PET-35, Petroleum Mechanical Engineering Conference, Houston, Texas, 1959, 3 *pp.*

electrical

Printed Circuits in High-Volume Electronic Equipme

D. D. Israel, Emerson Radio & Phonograph Corp.

Major reasons for using printed circuits in quantity production of electronic equipment. Reasons are miniaturization requirements, process mechanization, performance uniformity, reliability improvement, and cost reduction. Each is discussed in some detail.

IRE paper, IRE Third National Conference on Production Techniques, San Mateo, Calif., June, 1959; 2 *pp.*

Power Transmissions—Applications and Performance

R. W. Bachmann, Twin Disc Clutch Co.

A review of performance features of three basic power-transmission drive devices. These include the clutch, fluid coupling, and hydraulic torque converter. Output - performance characteristics, rather than specific design features, are compared. Results indicate that no particular type of drive is categorically superior to others. Clutch drives are suitable if the operating load for a given application is to be virtually constant and if occasional shock loads and torsional vibrations are not excessive. A certain amount of overload protection is obtained with a clutch drive by overpowering the application.

Fluid couplings, unlike the plain clutch drive, offer protection to the drive and driven machinery from shock loads and torsional vibration. The fluid-coupling drive offers overload protection similar to the clutch

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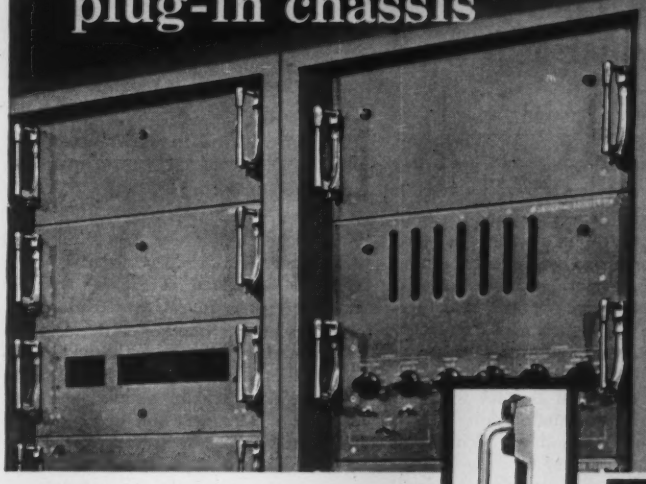

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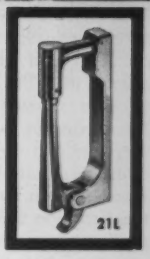

Thirty-eight strong, simple, attractive Camloc multi-function Chassis Latches are used on the 24 equipment filled plug-in chassis that make up DATICO, the military's new universal automatic field service checkout system. Here is a perfect example of designed-in fastener serviceability, flexibility, ease of handling and economy in interconnected "black-box" systems. When the Camloc push-button handles are released and pulled down, the chassis is automatically disconnected and ejected. Then the latch becomes a carrying handle. When replacing the equipment the latch firmly pulls the chassis back in place, making perfect, automatic reconnection of multiple-pin units. It is quick, safe, reliable, vibration-proof. Camloc Chassis Latches consist of only two parts—a handle and a fork—mounted with standard screws. Several handle and fork designs are currently available, all interchangeable. *Write for Camloc's new Bulletin 35L today.*

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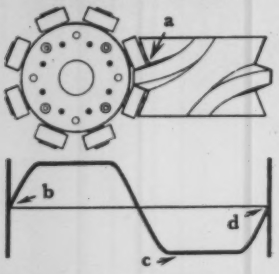
(Advertisement)
DESIGN CONSIDERATIONS

Critical Points in Acceleration Characteristics of Indexing Devices

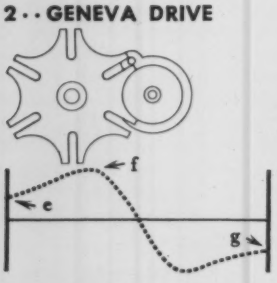
Maximum speeds of production machines are frequently affected by performance limitations of their indexing mechanisms. The efficiency of the indexing mechanism, itself, is dependent upon the amount of shock, vibration and other dynamic forces involved in the starting, stopping and rate of change from maximum acceleration to maximum deceleration.

FIG. 1 · · FERGUSON DRIVE



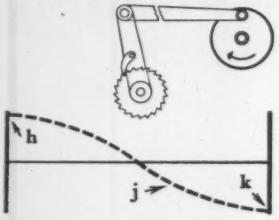
The acceleration curves of such mechanisms provide a graphic means of evaluating and comparing dynamic conditions that affect the performance of the indexing device and the machine. The Ferguson Drive in Fig. 1 is a cam indexing mechanism employing preloaded bearing followers rolling along a tapered cam rib. Two followers are in contact with the rib at all times (a) maintaining a zero backlash condition and an accuracy of .001″ without auxiliary locating devices. This Drive features a modified trapezoid acceleration characteristic . . . a combined cycloidal and gravity curve. The Ferguson Drive has an initial force of zero (b) and a smooth, sinusoidal increase. Its maximum acceleration value (c) is very low and the change through maximum deceleration to zero (d) is gradual. These smooth indexing characteristics of the Ferguson Drive permit operation of production machinery at speeds as high as 2,000 RPM, if necessary, with a minimum of 8,000 hours operation while maintaining extreme precision and zero backlash.

FIG. 2 · · GENEVA DRIVE



The six-stop geneva drive shown in Fig. 2 is representative of the geneva family in that its dynamic forces are instantaneously applied and the initial acceleration force is fairly high (e) with an even higher maximum acceleration (f). The change to maximum deceleration is gradual but there is an almost instantaneous stop (g). When operated at high speeds, geneva drives wear out quickly and cause heavy vibrations that seriously affect the life of the machine and product quality.

FIG. 3 · · RATCHET & CRANK



The rachet and crank has a distorted cosine acceleration curve (a true cosine curve is illustrated in Fig. 3) with an extremely high initial acceleration (h). The descent to maximum deceleration (j) is gradual but, as with the geneva drive, stopping is instantaneous (k). Even with auxiliary braking action, overtravel is extreme and accuracy is very poor. Rachet and crank devices have very limited use in modern production machines.

FIG. 4 · ·

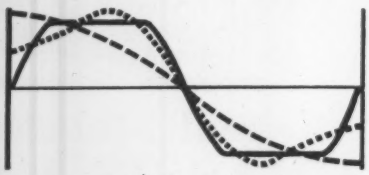


Fig. 4 shows the curves of the three mechanisms on the same diagram. Note that only the Ferguson Drive has an initial force of zero and the lowest maximum acceleration value combined with a gradual change to maximum deceleration. *This is why the Ferguson Drive does what no other indexing device can do!*

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Complete information about the Ferguson Drive is available in the form of an easy-to-use catalog containing load ratings and dimensions of many standard units, drawings and installation photos. There is a copy for every design engineer . . . for your copy write: **Ferguson Machine Corp., 7818 Maplewood Industrial Court, St. Louis 17, Missouri.**

drive. It may be incorporated into a power-shift, step-geared transmission for taking up shock loads when shifting from one gear to another under full power. Torque-converter drives are suitable for applications where load varies considerably throughout the work cycle. Overload protection is greater with torque-converter drives. With adequate cooling, the working range is broader with this type of drive. Operating conditions which affect selection of a drive are analyzed.

ASME paper 59-MD-6, Design Engineering Conference, Philadelphia, May, 1959; 8 *pp.*

hydraulic

The Sonic Pump

G. A. Bodine, Bodine Soundrive Co.

Theory on which the sonic pump has been developed and details of practical application and performance. The author briefly and generally discusses functions of the sonic pump, how a liquid is impelled, relation of fatigue to design, and compares sonic transmission of energy to electrical transmission of energy.

ASME paper 59-PET-18, "The Sonic Pump For Wells," *ASME Petroleum Mechanical Engineering Conference, Houston, Tex., September,* 1959; 4 *pp.*

Fluid Sealing in Extreme Environments

A. A. LePera, Wright Air Development Center.

Design criteria for elastomeric seals for various fluid systems and their respective environments. Some analysis of seal failure is included. Topics covered are fluoroelastomers, O-ring seals, antiextrusion devices, O-ring performance data, metal seals, and propulsion systems. The report indicates that new inorganic composite seals are being developed. These seals combine desirable characteristics common to elastomers and temperature resistance to at least 1000 F. Several composites consisting of a sintered stainless-steel fiber network filled with various soft ductile phases have been fabricated into seal configurations. Other approaches under consideration in-

clude investigation of metallo-organic compounds, inorganic polymers containing boron, nitrogen, and phosphorus; and compressible ceramics obtaining compressibility through molecular interlayers.

SAE paper 50U, SAE National Aeronautic Meeting, New York, 1959; 7 *pp.*

Viton O-Ring Seals

F. H. Pollard, Republic Aviation Corp.

Thermal capabilities and design criteria for O-ring seals molded of Viton and elastomeric materials. Emphasis is on sealing problems in hydraulic cylinders and other components.

SAE paper 50R, SAE, National Aeronautic Meeting, New York, 1959; 4 *pp.*

materials

Rupture Characteristics Of Safety Diaphragms

N. A. Weil, The M. W. Kellogg Co.

Investigation of maximum-pressure criteria for materials obeying a parabolic stress-strain law. Two special solutions are formulated and are accompanied by the instability condition obtained from the author's approximate theory. Bursting pressure is most accurately predicted by the approximate theory. In turn, the polar deflection and strain at instability are more closely predicted by a special solution. The author points out that neither the "pureness" nor the annealed condition of a metal gives adequate assurance of reliability in frangible disc service. Conclusions indicate that if a large deflection prior to bursting is desired, safety diaphragms should be constructed of materials with high values of m, the strain-hardening exponent. On the other hand, if a high bursting pressure is to be attained, a material with a high A-value (hardness factor, psi) should be chosen regardless of its strain-hardening exponent. It has been recommended that, for consistent and reliable performance, only "pure" metals in the annealed condition should be used in the manufacture of safety diaphragms. However, this reasoning appears to be in error. The fact is that the repro-

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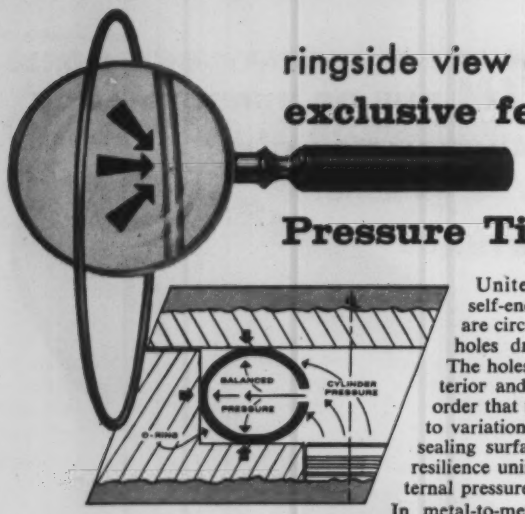

ringside view of United's **exclusive feature** for

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United's exclusive, patented* self-energized metallic O-rings are circular tubes vented by tiny holes drilled in the ring wall. The holes are to balance the interior and exterior pressures in order that the ring may respond to variation in deflection of the sealing surfaces with a natural resilience uninhibited by the external pressure.

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PATENTS 2,809,269; *2,837,360

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Circle 503 on Page 19

ducibility of bursting pressures depends only on the ability of a metal to stretch until the bulge passes through instability. Many pure metals, specifically certain grades of aluminum alloys, do not possess this ability.

ASME paper 59-APMW-3, ASME West Coast Conference of the Applied Mechanics Division, Stanford, Calif., September, 1959; 4 *pp.*

Ceramic Adhesives

H. G. Lefort, University of Illinois

A progress report on ceramic adhesives suitable for bonding metals. Yield shear strength in excess of 2000 psi at temperatures to 1000 F are possible. At 800 to 1000 F, shear values are expected to approach 4000 psi. Values such as these are more than a third of the strength developed by organic adhesives at room temperature and greatly exceed the strength of organics as the temperature is raised above a few hundred degrees Fahrenheit.

Variables which affect shear strength include thermal expansion of the adhesives and metal, surface preparation of the metal, adhesive slip properties, size and shapes of carriers, thickness of the adhesive joints, area of overlap, discontinuities in the adhesive layer, and action of powdered metals added to the adhesive slip.

PEI paper, Proceedings of the Porcelain Enamel Institute Forum, Vol. 20, *pp.* 121-130.

Thermodynamic Properties Of Helium Below 20 K

D. B. Mann, National Bureau of Standards and R. B. Stewart, University of Colorado

A compilation and correlation of present data on thermodynamic properties of helium below 20 K presented in the form of two convenient charts. Resulting diagrams include properties of pressure, volume, temperature, enthalpy, and entropy for pressure to 100 atm, for specific volume from 5 to 800 liters per kilogram, and for temperatures between 3.0 and 20 K. The first of these charts uses temperature-entropy coordinates which are generally useful in analysis of

Circle 504 on Page 19→

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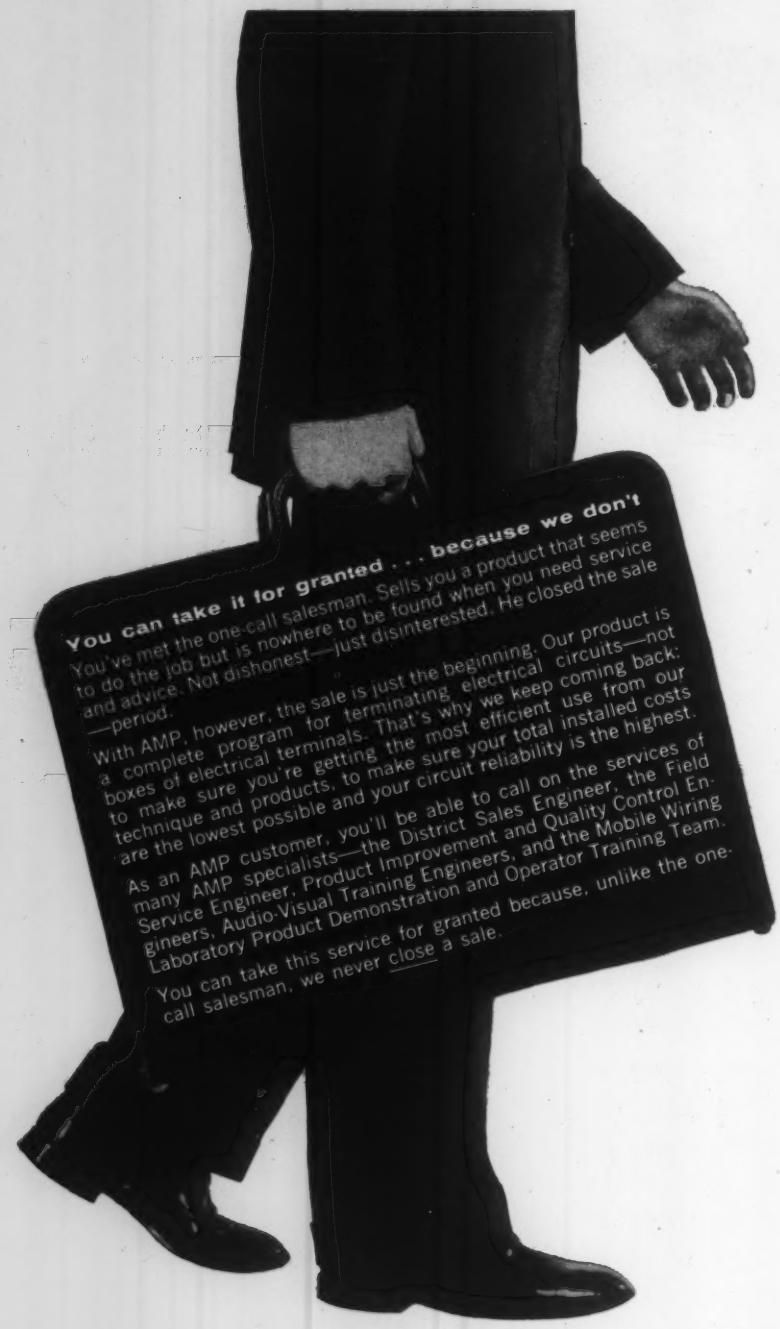
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thermodynamic systems and processes. The second chart presents data with enthalpy-entropy coordinates. The second chart is necessary since slopes of volume, pressure, and enthalpy lines approach a common value in the compressed liquid region on the temperature-entropy plaque, making interpolation difficult and inaccurate. This graph is not extended to low pressures and high temperatures since the temperature-entropy diagram published by J. Zelmanov is adequate for these regions. Values presented on the charts are accurate to within 5 per cent and in most cases to within 3 per cent.

ASME paper 59-HT-19, "Thermodynamic Properties of Helium at Low Temperatures and High Pressures," ASME-AIChE Heat Transfer Conference, Storrs, Conn., August, 1959; 4 pp.

Developments in Corrosion-Resistant Materials

S. W. Shepard, Chemical Construction Corp.

A survey of improvements in existing engineering materials. New forms, new combinations, increased availability, and effective use are analyzed. Materials include aluminum, organic coatings, iron, nonferrous metals, plastics, rubber, titanium, uranium, and zirconium.

ASME paper 59-MD-7, Design Engineering Conference, Philadelphia, May, 1959; 13 pp.

Refractory-Metal Thermocouple

J. C. Lachman, General Electric Co.

A study of thermoelectric properties of refractory metals with emphasis on the use of rhenium for thermocouple applications. The pure-metal combinations of rhenium versus molybdenum and rhenium versus tungsten are calibrated to 40,000 F in vacuum, hydrogen, and inert-gas atmospheres. Rhenium-molybdenum and rhenium-tungsten thermocouples have a high thermal emf which is reasonably linear with temperature. Practical application of rhenium-molybdenum is limited to about 3200 F by loss of thermoelectric potential. Rhenium-tungsten thermocouples, however, measure temperatures to 4000 F and appar-

ently higher. Discussion includes practical applications of the thermocouples and availability of required materials, cost comparison with present commercial thermocouples, and outlook for future development.

ASME paper 59-HT-21, ASME-AIChE Heat Transfer Conference, Storrs, Conn., August, 1959; 10 pp.

mechanical

Static and Dynamic Behavior of Flexible Torsional Couplings

A. Seireg, The Falk Corp.

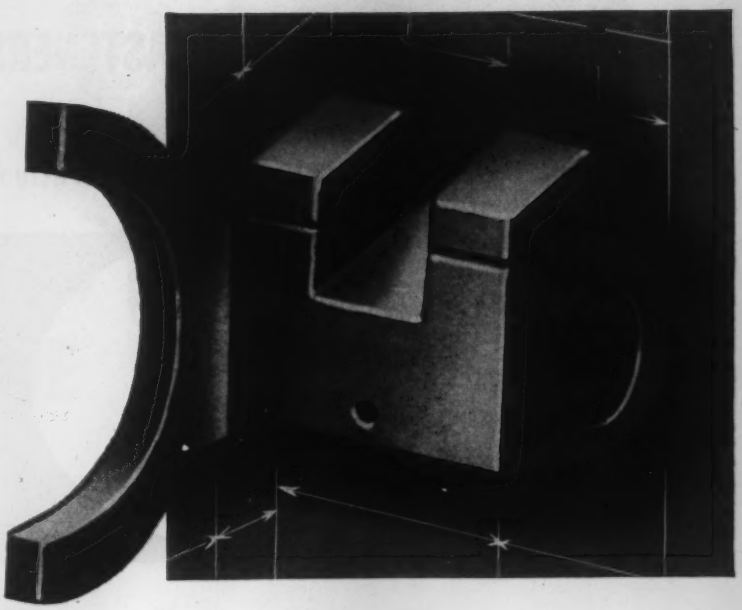
Static torque-deflection relationships for couplings with nonlinear characteristics. The procedure shows good agreement with steady-state experimental results obtained by testing the coupling in a single-degree-of-freedom vibratory system. Results indicate that static torque-deflection loops can be used to predict equivalent thickness factors for the nonlinear coupling undergoing different vibratory cycles. These equivalent linear factors can be used satisfactorily in vibration analysis of systems containing the coupling. The area of the static hysteresis loop for cycles with small amplitudes gives an approximate estimate of the contribution of internal losses in the coupling to the total damping in a vibratory system.

ASME paper 59-SA-8, ASME Semi-annual Meeting, St. Louis, Mo., June, 1959; 8 pp.

Applications of Auxiliary Powerplants

D. L. Cochran, A. T. Biehl, D. R. Salle, and M. R. Gustavson, Aerojet-General Nucleonics, and A. M. Taylor, Aerojet General Corp.

Analysis of the general problem of nonairbreathing auxiliary power systems. On the basis of minimum weight, it is recommended that systems such as batteries, fuel cells, and solar cells be used for less than a few kilowatts of power. Choice depends mainly upon required duration. For powers larger than a few kilowatts, either chemical propellants combined with mechanical conversion systems or nuclear power systems should be used. Chemical propellant systems are required for durations of a few hours and less,



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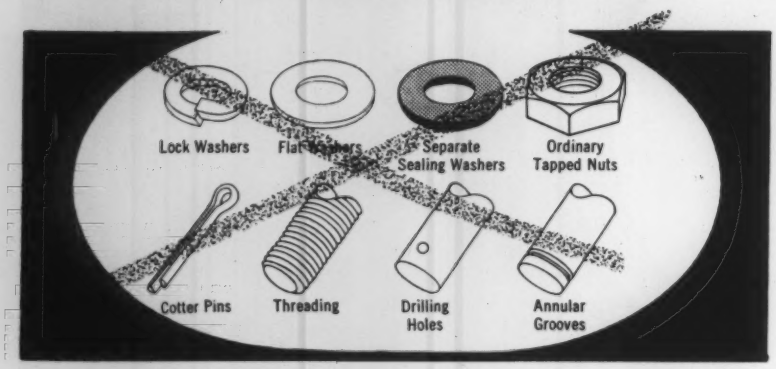
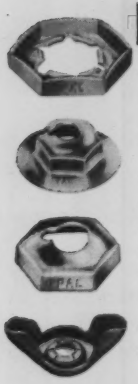
one or more of these assembly parts or operations



–and provide compact, vibration-proof assemblies



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and nuclear systems must be used for times greater than a few hours. Various types of chemical propellants and mechanical conversion systems are described. Problems involved in a nuclear power system are considered in detail, and characteristics of a typical advanced state-of-the-art systems are described. Thermodynamic properties are included for several fluids that might be used for such a system.

SAE paper 53T, SAE National Aeronautic Meeting, New York, 1959; 23 *pp.*

Design of a Dust-Tight Screw Conveyor

A. L. Lyons, Monsanto Chemical Co.

Case-history treatment of major design features of the new Monsanto standard design for dust-tight, carbon-steel screw conveyors (6 to 18-in. diam). Design considers long life with minimum maintenance, economical and rugged construction, dust-tight features, and conformity with vendor standards where practical. Features covered include the conveyor screw, hanger bearings, flanges, couplings and shafts, and determination of torque, capacity, and horsepower.

ASME paper 59-SA-5, *ASME Semi-annual Meeting, St. Louis, Mo., June,* 1959; 4 *pp.*

Logic Circuits for Machine Control

E. V. Weir, Magnetics Inc.

A discussion of basic problems involved in the application of control systems to machines. The basis of operation of three widely used static-control systems is covered together with possibilities and limitations in applications of relays, contactors, and static or magnetic-amplifier type systems.

ASME paper 59-MD-10, *Design Engineering Conference, Philadelphia, May,* 1959; 12 *pp.*

processes

Deformation of Materials by High Energy Rates

J. B. Ottestad, General Dynamics Corp.

A state-of-the-art report on the plastic-deformation process. Plastically working metals at tempera-

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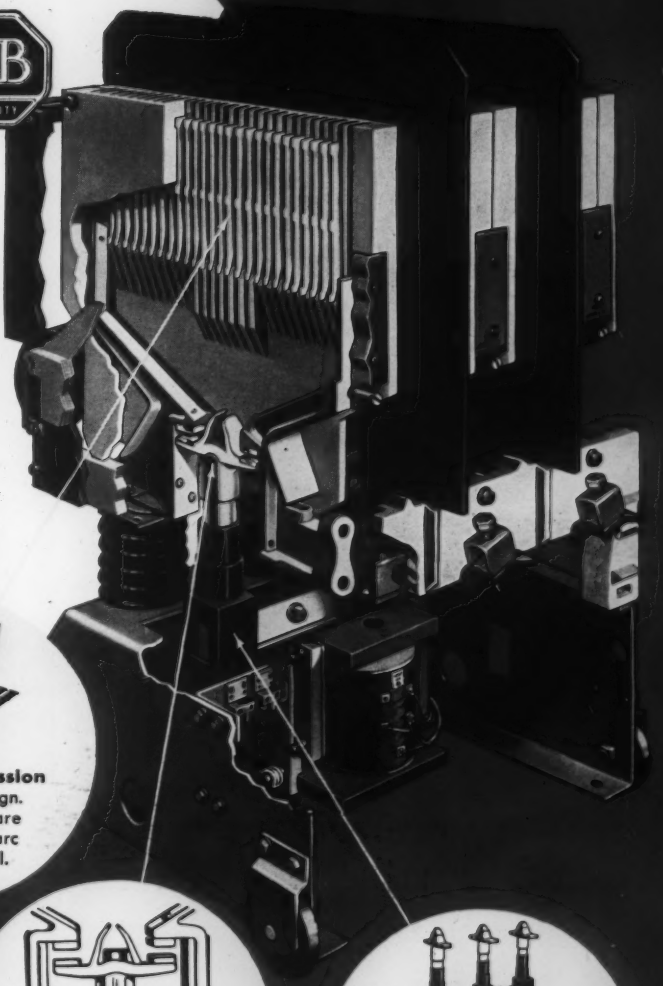

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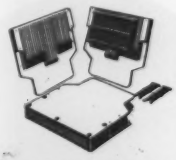

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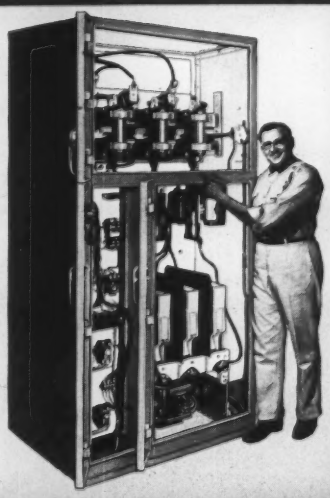

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Bulletin 1159 high voltage air break, across-the-line induction motor starter in NEMA Type 1 enclosure. All Allen-Bradley high voltage starters are equipped with current limiting fuses with interrupting capacities of 150,000 kva at 2300 v; 250,000 kva at 4600 v.

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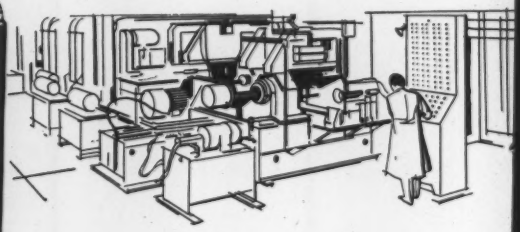

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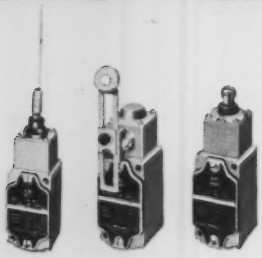

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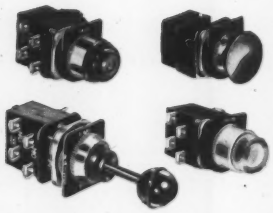

OILTIGHT CONTROL UNITS
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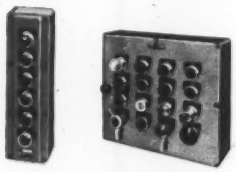

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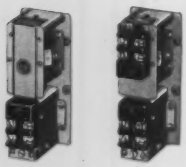
Bulletin 800T for up to 16 units in die cast aluminum enclosure.



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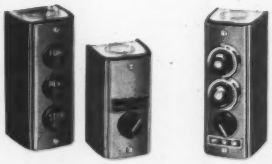

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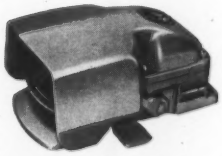

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tures below their natural melting points refines grain and flow lines to increase strength. Some accomplishments of this process include extruding tungsten at 4000 F with ratios of billet area to finished part area in excess of 40 to 1; forging aluminum, chrome-steel alloys, and stainless steel with zero draft angles; obtaining tolerances to 0.001 in. on parts 3 in. in diam and surface finishes of less than 18 microinches per inch; forming domes and cones 4 ft in diameter in 1/16 to 1 in. plates using total equipment weighing 1500 lb; forming precision sheets $\frac{1}{4}$ in. thick of high-alloy steel in 0.003 sec; and coextruding bimaterials where one material forms the core and another the exterior.

SAE paper 52T, SAE National Aeronautic Meeting, New York, 1959; 4 *pp.*

techniques

Nomographic Synthesis of Generator Linkages

D. P. Adams, Massachusetts Institute of Technology

A graphical technique for optimizing generator - linkage design by systematic scanning of five linkage parameters. A nomograph of linkage behavior, simplified through symmetry of quadrilateral relationships, fixes the optimum linkage as a rectilinear, horizontal plot from which a measure of error is available.

ASME paper 59-SA-11, *ASME Semi-annual Meeting, St. Louis, Mo.,* 1959; 10 *pp.*

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ASME—American Society of Mechanical Engineers, 29 West 39th St., New York 18, N. Y.; papers 25 cents to members, 50 cents to nonmembers.

IRE—The Institute of Radio Engineers, 1 East 79th St., New York 21, N. Y.

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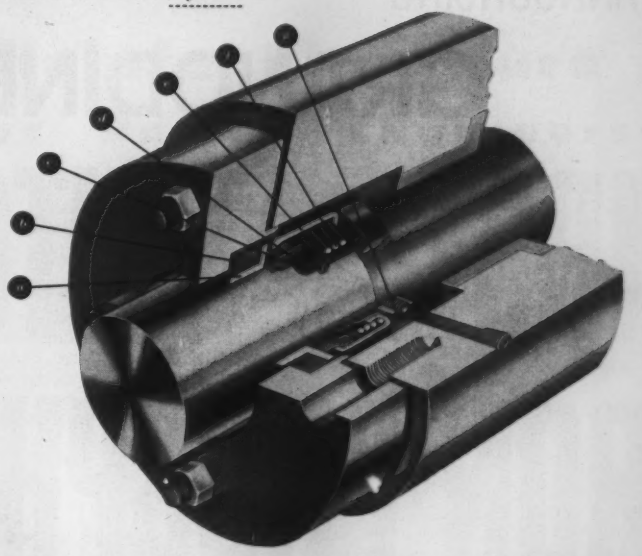

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a. ***Stationary Seat*** *of ceramic, Ni Resist, or bronze has precision lapped sealing face for perfect contact with carbon ring.*

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c. ***Seal Ring*** *of carbon is also precisely lapped to match sealing face of stationary seat.*

d. ***Roll type Bellows*** *permits free movement of seal ring.*

e. ***Shell,*** *encases entire rotary unit and furnishes mechanical drive for seal ring.*

f. ***Stainless Steel Spring*** *with load precisely calculated to face area of seal.*

g. ***Stop Collar,*** *or shoulder, positions seal to specified operating length.*

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ANNOUNCING

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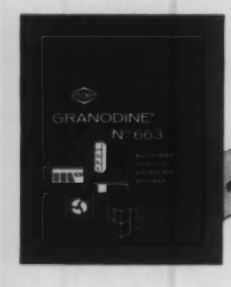

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Helpful Literature for Design Engineers

For copies of any literature listed, circle Item Number on Yellow Card—page 19

Air Compressors

Informative booklet entitled "Compressed Air Fundamentals" will aid in selection of a small package air compressor. It covers single and two-stage compressors, piston displacement, actual delivery unloading of compressors, regulation and types of control. 16 pages. Ingersoll-Rand Co., 11 Broadway, New York, N. Y. C

Circle 641 on Page 19

Silver-Cadmium Batteries

Silcad long-life silver-cadmium cells are one-third the weight and one-quarter the size of ordinary batteries, according to folder which supplies extensive physical and electrical data on these cells. Batteries are widely used in the portable electronics field. 6 pages. Yardney Electric Corp., 40-50 Leonard St., New York, N. Y. D

Circle 642 on Page 19

Aluminum Rod

Immediately available from distributors throughout the country, cold processed aluminum rod and screw stock is made in various alloys. Technical information plus advantages of this material are given in Bulletin OA-22. Stak-Pak system of packaging aluminum rod and bar stock is explained. 8 pages. Olin Mathieson Chemical Corp., Metals Div., 400 Park Ave., New York 22, N. Y. D

Circle 643 on Page 19

Small Magnetic Clutches

Conforming to MIL-specs, Type C-18 electromagnetic clutches are detailed in illustrated data sheet. Output torque is 80 oz-in. minimum, and recommended maximum operating speed is 5000 rpm. They operate on 24-v dc, but can be supplied for 1.5 to 300-v dc operation. 2 pages. Guidance Controls Corp., 110 Duffy Ave., Hicksville, L. I., N. Y. D

Circle 644 on Page 19

Temperature Control

Bulletin MC-179 describes Series 535 transistorized thermistor controller, covering specifications, temperature sensing probes, and suggested applications for packaging, printing, synthetic fiber processing, and general industrial storage. 2 pages. Fenwal, Inc., Pleasant Street, Ashland, Mass. B

Circle 645 on Page 19

Lighted Panel Switches

Complete Twinlite line of lighted push-button panel switches for computers, office machines, machine tool controls, and instrument panels are featured in Bulletin 55. They combine lighting, legend, and switching in one unit that requires about 1 sq in. of panel space. 6 pages. Electrosnap Corp., 4218 W. Lake St., Chicago 24, Ill. J

Circle 646 on Page 19

Submersible Motors

Rated ½, ¾, and 1 hp, Submatic electric motors are of capacitor start, induction run types. They are sealed in bronze case which serves as a switch-actuating float to operate in and under water, the level of which determines the on-off position of the switch. They are designed for powering sump pumps. Details are given in Bulletin P-86026. 2 pages. Franklin Electric Co., Bluffton, Ind. J

Circle 647 on Page 19

Ground Steel

Over 1000 sizes of oil hardening and air hardening, low carbon, precision ground tool steels are listed in illustrated price and stock list. Each item is described, and uses and heat treat characteristics are covered. 16 pages. Peninsular Steel Co., Box 3853, Detroit 5, Mich. T

Circle 648 on Page 19

Centrifugal Blowers

Fifty-four flow charts, electrical specifications, and dimensions on blower units with free-air ratings of 18 to 270 cfm are included in illustrated catalog "Centrifugal Blowers." They operate on various voltages and frequencies in the range of 60 to 1000 cps. They are designed for air cooling. 12 pages. Air-Marine Motors, Inc., 369 Bayview Ave., Amityville, L. I., N. Y. D

Circle 649 on Page 19

Ball Bearings

Double row ball bearings, including open, shielded, and snap ring types, are subject of illustrated Bulletin 111. Designed for use under conditions involving heavy radial loads, moderate thrust, shaft rigidity, and limited housing area, bearings are made in 0.3937 to 4.3307-in. bore diameters. 4 pages. Hoover Ball & Bearing Co., 5400 S. State Rd., Ann Arbor, Mich. T

Circle 650 on Page 19

Mine Pumps

Described in Bulletin 6ME-11 is a complete line of mine gathering pumps. They are made in 1½ to 3-in. sizes and feature corrosion resistant construction. Design features are shown. 8 pages. Gorman-Rupp Co., Mansfield, Ohio. G

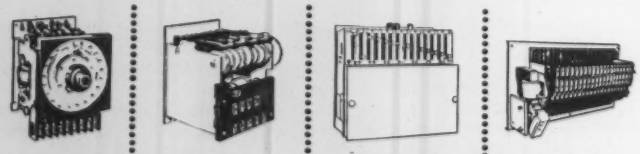
Circle 651 on Page 19

with easy-to-use *EAGLE* CYCL-FLEX reset timers

A highly accurate and dependable easy-to-use timer, designed for mounting in control panels. Sealed dial protects timer when exposed to oil and dust conditions. Timer switches control four load circuits. Interlocking contacts are provided without the use of auxiliary relays. Synchronous motor drive insures accurate timing.

WRITE for descriptive Bulletin 120. Address Dept. MD-1059.

EAGLE HAS 24 TYPES TIME-COUNT CONTROLS



Dial Timers and Counters | Cam Timers | Multi-Circuit Timers | Step Switch

EAGLE SIGNAL COMPANY
A DIVISION OF THE GAMEWELL COMPANY
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REPRESENTATIVES IN PRINCIPAL CITIES

Circle 511 on Page 19

HELPFUL LITERATURE

Flow Rate Indicator

Technical Data Sheet 51-1321B-1 describes features of the new transistorized servo-driven flow rate indicator. It is used with magnetic flowmeter primaries, 2 pages. Fischer & Porter Co., 153 Jacksonville Rd., Hatboro, Pa. E

Circle 652 on Page 19

Brazing Alloys

Various high purity brazing alloys for copper, bronze, or brass are presented in illustrated booklet. Specifications and cooling charts on standard alloy compositions for nonferrous brazing and similar data on silver solders for both ferrous and nonferrous metals are included. 8 pages. Alloy Specialties Co., Swissvale, Pa. F

Circle 653 on Page 19

Fuel Pumps

Balanced vane type fuel pumps for jet engines described in Bulletin A5242 meet rigid military specifications and afford substantial weight savings. The design and performance characteristics of these pumps are presented. 4 pages. Vickers Inc., Box 302, Detroit 32, Mich. T

Circle 654 on Page 19

Titanium Carbide

The advantages of titanium carbide alloys include resistance to temperatures of 1800° F and up, high stiffness-weight ratio, and resistance to thermal shock and oxidation. Physical characteristics of these materials, typical applications, and other design data are included in technical Bulletin B-444-A. 12 pages. Kennametal Inc., Latrobe, Pa. G

Circle 655 on Page 19

Electronic Components

Described in Catalog TF are power transformers, inductors, audio transformers, telephone coils, filters, toroids, jacks, plugs, panels, cords, and terminal blocks. Chart gives selection guidance for MIL-T-27A case sizes for transformers. 28 pages. Audio Development Co., 2833 Thirteenth Ave. S., Minneapolis 7, Minn. J

Circle 656 on Page 19

Resin Shapes

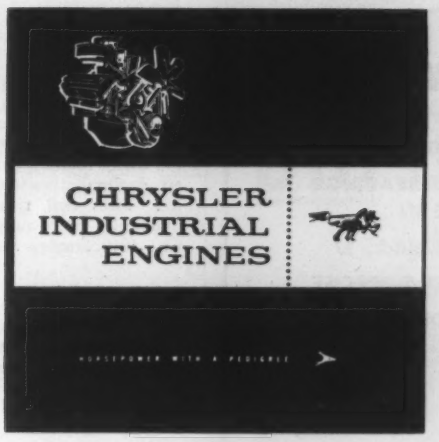
Polypenco Lexan polycarbonate mill shapes can be used as insulators, coil forms, flexible tubing, rollers, bushings, wear parts, and optical and transparent structural parts. This resin is readily machined and fabricated on metalworking machines. Complete data are given in Bulletin BR-12. 2 pages. Polymer Corp. of Penna., 2140 Fairmont Ave., Reading, Pa. C

Circle 657 on Page 19

Linear Transformers

Condensed semitechnical notes on the basic design of control systems using linear differential transformers as alternating current transducers with alternating or direct current outputs are contained in Bulletin 1201-A. Covered are simple circuits, mountings, and shielding. 8 pages. MinAtron Corp., 28 Cliveden St., Belle Mead, N. J. D

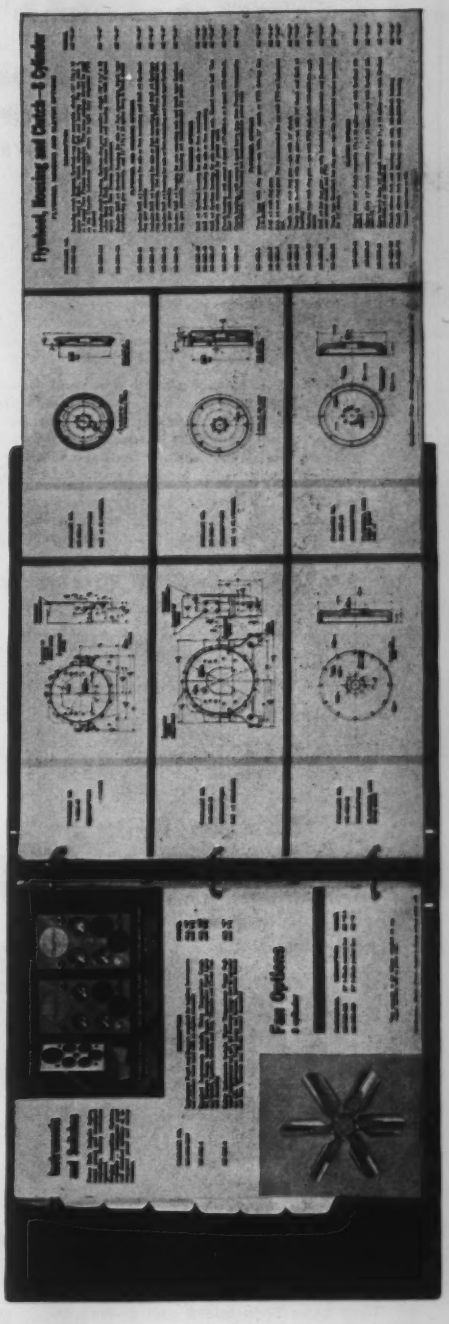
Circle 658 on Page 19



NEW CHRYSLER INDUSTRIAL ENGINE PRODUCT LINE CATALOG

helps you "build" and price an engine to fit your specific application—right at your desk.

Chrysler's new catalog gives complete details, drawings and specifications on all Chrysler Industrial Engines — 230 to 354 cu. in. displacement — plus complete details on all accessories and optional equipment. Thousands of combinations of engine, accessories and equipment are available. A simple code system helps you select and price the exact combination to fit your specific application. A call or letter will bring a Chrysler sales engineer with a copy of this catalog to "build" and price an engine *—right at your desk!*



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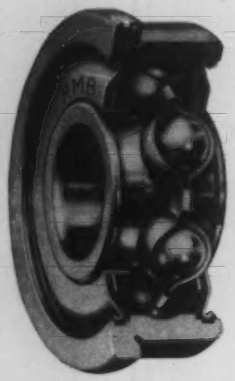
Circle 512 on Page 19



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RMB FLANGED,
SEALED MINIATURE BEARINGS
AVAILABLE IN
ABEC 1, 5, 7, and
THE NEW RMB ULTRA-PRECISE
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Now available in "Gyroscopic Quality" Tolerances, as well as the more familiar ABEC 1, 5, and 7, new RMB Filmoseal Flanged Bearings offer the engineer the ultimate in precision. Sizes range from 0.046" to 0.1875". Bore—0.1562" to 0.375" on.

RMB RF Filmoseal sealed miniature bearings combine all the advantages of sealed bearings with the rotational freedom of open bearings. Now you can get engineering features in bearings for small mechanisms that you would normally expect in larger size anti-friction bearings—There is no mechanical contact between rotating and stationary parts—Lubrication is retained and foreign matter excluded by oil encased, non-rubbing capillary seal.

Write to us for full details on these and the other miniature and instrument ball and roller bearings in the RMB line.

LANDIS & GYR, INC.
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Circle 513 on Page 19

VALLEY BALL BEARING MOTORS

Custom Built . . .
NOT Custom Priced!

AIR COOLED

- POLYPHASE, 50 OR 60 CYCLES
- SQUIRREL CAGE INDUCTION
- HIGH TORQUE
- ½ TO 75 H.P.

Cool Running . . . Continuous Service . . .

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They have been tested and proven in every industry where dependable service and power is a requirement. Remember they are semi-enclosed to assure protection against dripping or splashing liquids, metal chips and abrasive dust.

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Circle 514 on Page 19

HELPFUL LITERATURE

Rotating Unions

Cutaway drawings, charts, and engineering data are used in illustrated catalog to present complete design guidance in the use of rotating unions for water, steam, air, hydraulic, vacuum, and coolant service. Sizes and types are available for practically every need. 20 pages. Deublin Co., 1919 Stanley St., Northbrook, Ill. J

Circle 659 on Page 19

Inconel Tubing

Technical Bulletin CM-259 is entitled, "The Inconel Family of Small Tubing." Listed are the chemical composition, physical constants, and mechanical properties of five materials. Outer diameters of tubing range from 0.012 to 1.125 in. with various wall thicknesses. 4 pages. Superior Tube Co., Norristown, Pa. E

Circle 660 on Page 19

Blind Fasteners

Details of the design, application, and features of Sleev-Lok blind type panel fasteners in 3/16 to ⅜-in. diameters are given in Bulletin 2465. Also shown are power drivers and adapters for installing these panel, bulkhead, or sheetmetal fasteners. 8 pages. Standard Pressed Steel Co., Box 102, Jenkintown, Pa. C

Circle 661 on Page 19

Thread Inserts

How hole preparation cost is reduced, simplicity of insert installation, and methods of removal are covered in Bulletin 2-1601 on the new S110 insert which provides load bearing, wear resistant, self-locking threads in materials such as plate or cast aluminum. 4 pages. Hi-Shear Rivet Tool Co., 2600 W. 247th St., Torrance, Calif. L

Circle 662 on Page 19

Rubber Parts

Typical parts produced to customer specification, standard rubber parts, properties of natural and synthetic rubbers, available forms, and the company's design and production facilities are content of illustrated Brochure SR-59, entitled, "Stalwart Rubber Parts." Company offers engineering assistance in solving rubber parts problems. 24 pages. Stalwart Rubber Co., Northfield Rd., Bedford, Ohio. G

Circle 663 on Page 19

Teflon Sheet, Rod & Tube

Fact Sheet No. 3 gives available sizes, engineering data, and typical uses of molded Teflon sheets, rods, and tubes. Rods and tubes are offered in diameters to 10 in. Sheets range to thicknesses of 2 in. and sizes as large as 48 x 48 in. 4 pages. Chemplast, Inc., 3 Central Ave., East Newark, N. J. D

Circle 664 on Page 19

Electrical Connectors

Catalog 1416 contains comprehensive design and engineering data on several types of rectangular power connectors for electrical and electronic equipment and circuit applications. 20 pages. Continental Connector Corp., Woodside 77, N. Y. D

Circle 665 on Page 19

Polyethylene Resins

Issue No. 109 of "Kabelitems" lists requirements of new ASTM tentative specification D-1248-58T for polyethylene molding and extrusion materials. Also listed are Bakelite polyethylene resins and compounds for wire and cable applications meeting the specification. 6 pages. Union Carbide Plastics Co., 30 E. 42nd St., New York 17, N. Y. C

Circle 666 on Page 19

Porcelain Enameled Parts

Brief history of porcelain enameling, its applications, and properties are found in illustrated bulletin "Porcelain Enamel in Industry." Second Bulletin SC-58 shows a number of small porcelain enameled metal parts for functional and decorative applications and gives physical and surface properties. 20 and 4 pages. Erie Ceramic Arts Co., 3120 W. 22nd St., Erie, Pa. F

Circle 667 on Page 19

Torque Motors

Torque motors designed for specific applications are subject of Bulletin SDA T-1 and Engineering Bulletin SDA T-11. Former contains selection data, plus photos of typical applications. Second bulletin contains ratings of available motors. 4 and 2 pages. Peerless Electric Co., 1401 W. Market St., Warren, Ohio. G

Circle 668 on Page 19

Abrasive Wheels

Over 1600 abrasive wheel recommendations for grinding everything from agate to zirconium are found in specifications catalog. Types of abrasive, grit, grade, and bond are covered, as are type of operation and work. 60 pages. Carborundum Co., Niagara Falls, N. Y. N

Circle 669 on Page 19

Panel Meters

Indicating panel meters and pyrometers in various sensitivities, styles, and sizes for monitoring any electrically measurable variable are described in illustrated Bulletin 107. General specifications and prices are given. 12 pages. Assembly Products, Inc., Chesterland, Ohio. G

Circle 670 on Page 19

Screw & Nut Assemblies

Information on precision actuator screw and nut assemblies for use in atomic reactors, aircraft, machinery, instruments, etc., is contained in illustrated brochure. Diameters to 30 in. and lengths to 50 in. are offered. 4 pages. Jerpbak Bayless Co., Solon Road, Solon, Ohio. G

Circle 671 on Page 19

Flow Integrator

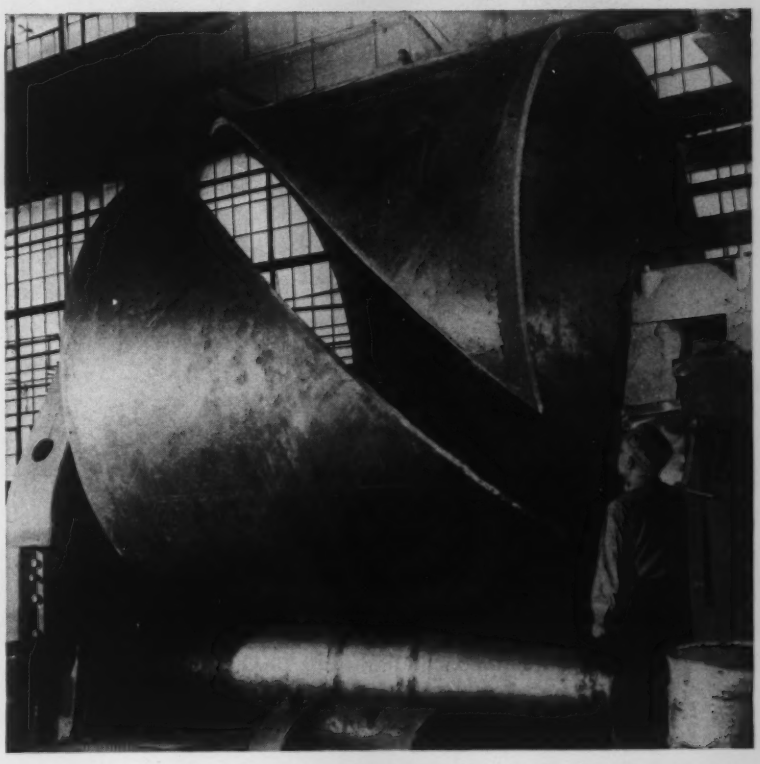
Frictionless method is used by the MPT-53 flow integrator to translate vertical motion of a rotameter metering float into a rotary motion. Integration is accomplished photoelectrically. Details of equipment are found in illustrated Bulletin 170. 12 pages. Brooks Rotameter Co., Box 432, Lansdale, Pa. E

Circle 672 on Page 19

AMPCO

BIG BRONZE PLATE!

Varying dimensions— up to 10,000 lbs. in weight



Here's an idea of what you can get in

AMPCO® METAL

A single Ampco Metal plate can be big enough (½" x 192" x 360") to form a tank 16' high x 11'-6" diameter! Big enough (1" x 180" x 240") to form a tank 15' long x 5'-3" diameter!

An Ampco Metal Tube Sheet 2" thick can be rolled 10'-6" in diameter. One 3" thick can be 9'-0" in diameter.

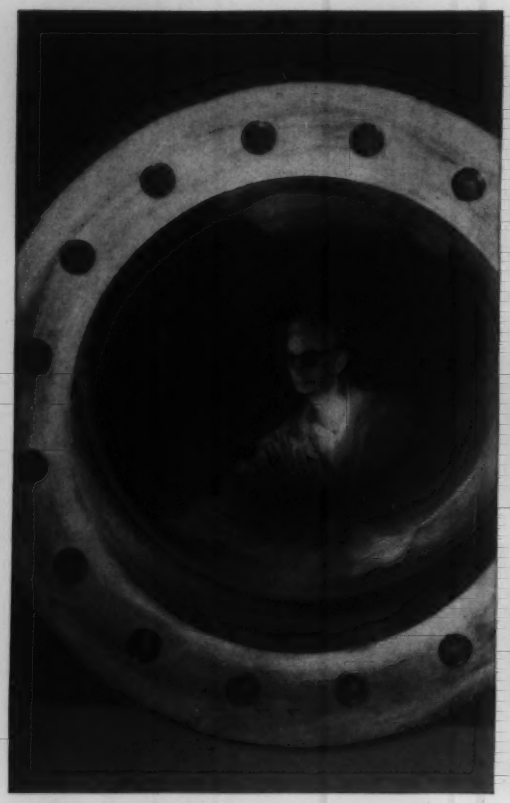
What are *your* requirements for corrosion, abrasion, or mechanical service? Talk it over with your Ampco field engineer. Write for bulletin.

C-23

AMPCO METAL

AMPCO METAL, INC.
Dept. 30-J, Milwaukee 46, Wis.
West Coast plant: Burbank, California
Southwest plant: Garland (Dallas County), Texas

Circle 515 on Page 19



You get greater strength . . . with

SHENANGO CENTRIFUGAL CASTINGS

Downtime, rejects, heavy maintenance costs and too-frequent replacements can be cut down *appreciably* by the use of Shenango extra-strong centrifugal castings.

They provide a finer, *pressure-dense* grain . . . with all the weakening defects eliminated, such as blowholes and sand inclusions.

Though built to stand the most rugged service, each Shenango casting is precisely-dimensioned to your exacting requirements. Whether you need rolls, bearings, bushings, mandrels, sleeves, liners, or any other essentially symmetrical part . . . *specify Shenango* for greater strength, greater wear-resistance, greater lasting power and greater savings, year after year.

Informative bulletins are yours for the asking. Write to: *Centrifugally Cast Products Division,* The Shenango Furnace Company, Dover, Ohio.

SHENANGO CENTRIFUGAL CASTINGS

COPPER, TIN, LEAD, ZINC BRONZES • ALUMINUM AND MANGANESE BRONZES
MONEL METAL • NI-RESIST • MEEHANITE METAL • ALLOY IRONS

Instrument Components

Over 10,000 gears, shafts, collars, couplings, speed reducers, differentials, and other precision items available from stock are listed in Master Catalog 20a. Along with specifications and prices is a separate breadboard kit and precision tool components section. 416 pages. Pic Design Corp., 477 Atlantic Ave., East Rockaway, L. I., N. Y. D

Circle 673 on Page 19

Aluminum Coated Wire

Aluminized steel wire and wire products, including steel core wires for aluminum cable, steel strand guy wire, and overhead ground, tie, messenger, telephone, and barbed wires are subject of illustrated Folder DH-537B. Properties and uses of hot dip aluminum coated wires and wire products are listed. 6 pages. American Chain & Cable Co., Page Steel & Wire Div., Monessen, Pa. B

Circle 674 on Page 19

Hoist Trolleys

Hoist trolleys for $\frac{1}{8}$ to 5-ton capacity hoists which fit all beams from 3 in. up are described and illustrated with engineering drawings in bulletin. Also detailed are conveyor and geared wheels for material handling equipment. A separate bulletin covers conveyor wheels. 6 pages each. Grey Hub Trolley Wheel Co., 17265 Gable Ave., Detroit 12, Mich. T

Circle 675 on Page 19

Metal Forming Methods

"One 'Metalman's' Family" is title of folder which holds bulletins describing three metal-moving services available from this company—upset forging, Rotaforming, and stamping. Typical products are shown for each production method, and limitations, tolerances, and applications are discussed. 4 pages each. Commercial Shearing & Stamping Co., Youngstown 1, Ohio. G

Circle 676 on Page 19

Titanium

"Titanium Metals Handbook for the Chemical Processor" covers the metal's behavior in some 200 corrosion environments. Use of conventional equipment for tube and sheet metal bending, drawing, surface treatment, machining, annealing, pickling, welding, and assembly is covered. Cast history data are included. 36 pages. Titanium Metals Corp. of America, 233 Broadway, New York 7, N. Y. D

Circle 677 on Page 19

Snap-Acting Switches

Sealed switches for severe environments and low cost switches for mass-produced automatic equipment are new units described in Catalog 359 on Unimax snap-acting precision switches. General purpose, low force, high sensitivity, open blade, environment free, metal-cased, AN and JAN, and reset types are also covered. 28 pages. W. L. Maxson Corp., Ives Road, Wallingford, Conn. B

Circle 678 on Page 19

Circle 516 on Page 19

. . . MICROMETER SETTING

For Exacting Flow Control

HANNA *Flo-Set* VALVES

Hydraulic pressure to 1000 psi
Sizes ¼", ⅜", ½", ¾"
Temperatures to 250°F

Air, Oil, water operation to 250 psi
Sizes ¼", ⅜", ½", ¾"
Temperatures to 250°F

OTHER HANNA VALVES
include solenoid, pilot, hand and foot operated types

FOR AIR • OIL • WATER • OTHER FLUIDS

REGULATING cylinder speeds or controlling fluid flow of air, oil or water is so simple with Hanna Flo-Set Valves . . . you need only turn the valve body one revolution to adjust from zero to full pipe capacity. Micrometer-type graduations are numbered to indicate the percentage of pipe capacity. Once set, the position can be locked to avoid accidental change. Future resetting to a predetermined flow requires no guesswork.

Hanna Flo-Set Valves allow full flow in one direction—controlled flow in the opposite. Used in pairs, they regulate independently cylinder instroke and outstroke speeds. Hanna Flo-Set Valves assure uniform speed, smoother action and improved performance of cushioned and non-cushioned cylinders.

Valve sizes are ¼", ⅜", ½", and ¾" . . . a ¼" Jr. model, without graduations or locking collar, is available for light piping and tubing.

Whatever your problem of precision fluid control may be—you will find the best answer in Hanna Flo-Set Valves—designed, built and guaranteed by Hanna's 50 years of experience in hydraulics and pneumatics.

WRITE FOR LITERATURE AND COMPLETE DETAILS,
or consult your classified telephone directory or Thomas' Register for your nearest Hanna representative.

Hanna Engineering Works

HYDRAULIC AND PNEUMATIC EQUIPMENT . . . CYLINDERS . . . VALVES

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Circle 517 on Page 19

IMMEDIATE DELIVERY!

ON 3/8" AND 1/2" O.D.

Non-Magnetic

18-8 TYPE 303 STAINLESS

UNIVERSAL JOINTS

Manufacturers of electronic equipment have come to depend on Curtis for precision-made non-magnetic universal joints of 18-8 Type 303 stainless steel, in the sizes most frequently used in the industry. Other sizes are also readily available; also bronze joints.

Curtis joints benefit by a rigid insistence on uncompromising inspection and quality control at every stage of manufacture, insuring minimum backlash.

Curtis torque and load ratings are entirely dependable, since they are based on continuous testing under actual operating conditions.

Not sold through distributors. It will be to your advantage to write or phone (REpublic 7-0281) for free engineering data and price list.

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UNIVERSAL JOINT CO., INC.
5 Birnie Avenue, Springfield, Mass.

As near to you as your telephone

A MANUFACTURER OF UNIVERSAL JOINTS SINCE 1919

Circle 518 on Page 19

HELPFUL LITERATURE

Servomotors

Electrical and mechanical specifications, dimensional drawings, schematics, and torque-speed curves are presented for Size 15 servomotors, servomotor-rate generators, inertia-damp, and adjustable velocity servomotors. 16 pages. Beckman Instruments, Inc., Helipot Div., 2500 Fullerton Rd., Fullerton, Calif. L

Circle 679 on Page 19

Bushings & Washers

New information on dry bushings and thrust washers made of Teflon-lead dry bearing material which covers alternate installation tolerances and instructions for fitting is content of Bulletin DU-458A. Available sizes are listed. 4 pages. United States Gasket Co., Camden 1, N. J. E

Circle 680 on Page 19

Weighing Systems

The basic art of weighing, accuracy in weighing systems, Emery "rolling ball" head, and instrumentation used with modern weighing systems are subjects of four folders dealing with industrial weighing. They contain basic data and are suited for collecting competitive data. A. H. Emery Co., Pine Street, New Canaan, Conn. B

Circle 681 on Page 19

Armature Assembly

Spline drive armature assembly for heavy duty applications is described in Bulletin P-68. Assembly and disassembly information and pictures are included for the drive, developed for use with primary brakes and clutch-couplings. 4 pages. Warner Electric Brake & Clutch Co., Beloit, Wis. K

Circle 682 on Page 19

Bronze Alloy

Duronze 708 for valve parts is an alloy of aluminum silicon bronze-copper, alloyed to aluminum and silicon in varying degrees, with arsenic added for corrosion resistance. According to technical data sheet it has high strength, good machinability and fatigue resistance. 2 pages. Bridgeport Brass Co., Bridgeport 2, Conn. B

Circle 683 on Page 19

Electrometers

Linear, log, differential current, dual linear, and dual log types of electrometers are described and illustrated in Form 3026-9. Detailed specifications, including current ranges, stability, and accuracy ratings, are presented. 8 pages. Victoreen Instrument Co., 5806 Hough Ave., Cleveland 3, Ohio. G

Circle 684 on Page 19

Potentiometer

Concentric shaft potentiometer, subject of illustrated data sheet, consists of two precision potentiometers assembled in tandem for design simplification and savings in space. Detailed specifications are given. 2 pages. Waters Mfg., Inc., Wayland, Mass. B

Circle 685 on Page 19

IT PAYS TO HAVE GOOD CONNECTIONS — HUBBELL

Manufacturers of Cold Headed Fasteners Since 1888

Hubbell has the capacity to produce and deliver on time the finest quality standard or special fasteners in the quantity required up to a maximum diameter of 1⅛". This statement is backed by the facilities listed here and supported by over 70 years' experience in cold heading.

Each operation is quality controlled to insure high quality and precision.

COLD HEADING

SLOTTING

Mass production is maintained without sacrificing accuracy or quality.

THREAD ROLLING

TURNING POINTING

The use of our engineering service offers the ultimate in engineering know-how.

DRILLING TAPPING

Prices and delivery on request. Simply send blueprint and/or sample of the item.

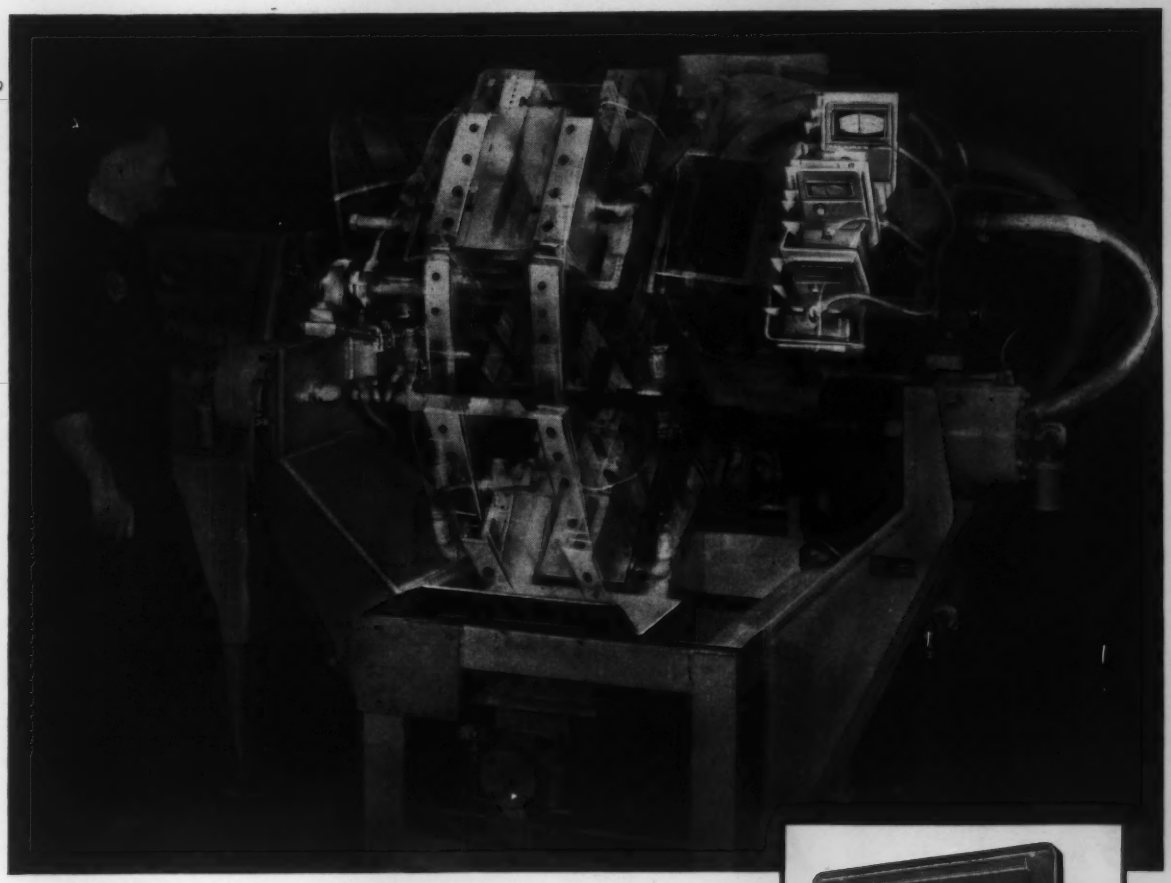
PLATING HEAT-TREATING

QUALITY CONTROL

HARVEY HUBBELL, INCORPORATED

Machine Screw Dept. Bridgeport 2, Conn.

Circle 519 on Page 19



A Partlow Model MFS indicating controller is shown in action in this "multiple exposure" shot of a Holo-Core Automatic Molding Machine manufactured by Spo, Inc., Cleveland, Ohio.

The Temperature Control Built to
SHRUG OFF SHOCK
2438 Times a Day

Every working day, the Partlow Temperature Control in this photo takes between 2400 and 2500 solid "roundhouse punches" from the shell-molding machine to which it is attached.

But despite jarring shock and vibration, and a constant barrage of foundry dust, the Partlow goes right on delivering precision control—without letup or breakdown.

Actually, only a control as simple and rock-solid as the Partlow could withstand this kind of punishment! Because only the Partlow contains no hairsprings, or delicate gadgets.

All Partlow thermal elements of the same range are interchangeable *on the job*, too. There's no time lost waiting for your control to come back from the factory. And you get this extra margin of dependability *without loss of accuracy*. Partlow controls are precise to within 1% of scale in any one of 10 ranges from −30° to 1100° F.

If you use or manufacture equipment within this temperature range, there's a Partlow to fit your application exactly . . . and save you money, too. Available in Pneumatic, Electric or Self-Contained Gas types, in recording, indicating or non-indicating models! To field test any Partlow control . . . or to obtain full details write, The Partlow Corporation, New Hartford, N. Y. Dept. D-109.

Export Ad. Auriema, Inc., 85 Broad St., New York 4, N. Y.

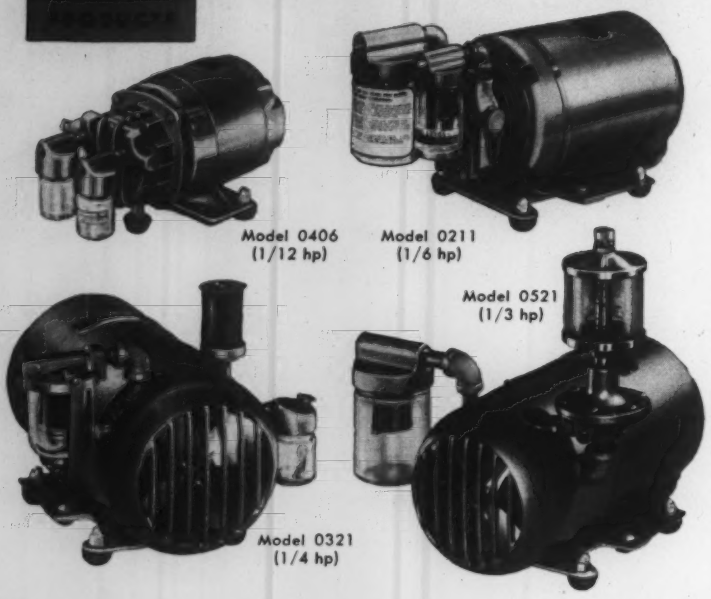
A complete absence of gadgets and superfluous parts, as seen in this open view of the new MFS indicating control, explains the Partlow's unique ability to function accurately even under the most severe operating conditions.

You can pay more but you can't buy better than

PARTLOW

TEMPERATURE CONTROLS

GAST VACUUM or PRESSURE . . .



For O.E.M., lab or plant use—specify compact, portable integral-motor

GAST rotary vane AIR PUMPS

Gast construction is precise—and prices are competitive!

To save space . . . and reduce weight and mounting costs—use Gast Integral-Motor-Pump Models! For vacuum use—or fitted as air compressors—four sizes offer capacities from ½ to 3.8 cfm.

For completely oil-free air, Models 0406 and 0211 are available with oil-less construction (optional). Lubricated Models 0321 and 0521 have fan cooling. Vacuum ranges to 28" Hg., pressures to 25 psi.

Rotary-vane design is positive in displacement, quiet and long-lived. That's why engineers specify Gast Air Pumps as components for air sampling, industrial and laboratory instruments; printing, packaging and vending machines.

To acquaint yourself with other advantages, write for Bulletins V-P-356.

GAST MANUFACTURING CORP., P.O. Box 117-P, Benton Harbor, Michigan

SEE CATALOG IN SWEET'S PRODUCT DESIGN FILE & A.S.M.E. CATALOG

GAST ROTARY

- AIR MOTORS TO 7 H.P.
- COMPRESSORS TO 30 P.S.I.
- VACUUM PUMPS TO 28 IN.

"Air may be your answer!"

HELPFUL LITERATURE

Rotary Switch

Flexibility in control of complex circuits is possible with the Type HT rotary multipole switch, subject of illustrated Bulletin 6. It is designed for tap, transfer, and selector service requiring interrupting rating up to 5 amp, 125 v ac. Mounting data are given. Electro Switch Corp., Weymouth 88, Mass. B

Circle 686 on Page 19

Packings

What Palmetto self-lubricating packings are and their advantages and applications on pump rods and shafts and valve stems are related in revised Catalog SLP-659. Each of 29 types is illustrated and described. Recommended services, temperature limits, sizes, and prices are given. 12 pages. Greene, Tweed & Co., North Wales, Pa. E

Circle 687 on Page 19

Strip Coating

Equipment for strip coating, a method of applying paints, lacquers, plastics, resins, etc., to coiled steel, tin plate, aluminum, or other metals before forming, is illustrated in Bulletin RW-500. Complete strip coating line is shown. 4 pages. Midland-Ross Co., J. O. Ross Engineering Div., 730 Third Ave., New York 17, N. Y. D

Circle 688 on Page 19

Tubeaxial Blower

Performance data, including rated delivery at various static pressures, are presented for the No. 89B222 Tubeaxial blower unit for ventilating electronic equipment in Bulletin 5912. The 1/70-hp, 1600-rpm unit has an 8-25/32-in. ID. 2 pages. American-Standard, Industrial Div., Detroit 32, Mich. T

Circle 689 on Page 19

Epoxy-Fiberglas Tubing

Technical data and properties relative to Chemtube seamless epoxy-Fiberglas tubing and other structures of silicone and urethane-glass fiber are provided in technical bulletins MSD-54A and 54B. Material has high insulating and electrical properties. 2 pages. Chemfab Corp., 40-30 23rd St., Long Island 1, N. Y. D

Circle 690 on Page 19

Welding

"How to Weld U. S. Steel's T-1 Steel" is title of pocket-size guide for fabricators and welders working with T-1 steel, both in the shop and in the field. A circular slide rule heat input calculator is included with the booklet. 24 pages. United States Steel, Room 2801, 525 William Penn Place, Pittsburgh 30, Pa. F

Circle 691 on Page 19

Stainless, Nonferrous Castings

Variety of stainless steel and nonferrous castings that can be cast by this company is illustrated in folder 240-R. Sleeve sizes together with estimated weights in 13½-in. lengths are tabulated. 6 pages. Vollrath Co., Sheboygan, Wis. K

Circle 692 on Page 19

Mechanical Drive

The Allispede mechanical adjustable speed drive covered in Bulletin 3600 operates on alternating current, affords speed ranges up to 8:1, and is available in 1 to 30-hp ratings. Engineering and application information are included. 6 pages. Louis Allis Co., 427 E. Stewart St., Milwaukee 1, Wis. K

Circle 693 on Page 19

Hydraulic Pump

The Vanguard two-stage hydraulic pump is rated 50 cu in. per minute at 10,000 psi. Bulletin V-1 describes this dual volume, dual pressure pump and illustrates examples of manifold, two-way valve, and four-way valve combinations. 2 pages. Owatonna Tool Co., Precision Hydraulics Div., Owatonna, Minn. J

Circle 694 on Page 19

Electrical Connectors

Outline and mounting dimensions for Series 2000 Continental rectangular connectors are provided in folder, along with electrical and mechanical ratings. Connectors have closed entry contacts in an aluminum shell. 4 pages. DeJur-Amsco Corp., 45-01 Northern Blvd., Long Island City 1, N. Y. D

Circle 695 on Page 19

Clock & Interval Timers

AMT-1 Series of clock and interval timers for gas and electric ranges are covered as to operation, dimensions, and features in Bulletin GEA-6804. 2 pages. General Electric Co., Schenectady 5, N. Y. C

Circle 696 on Page 19

Fasteners

The packaged bolts, screws, tapping screws, wood drive screws, and other fasteners carried as shelf stock for immediate delivery are listed in Bulletin SPG-3. Sizes and finishes are detailed on over a half-million items. 8 pages. Write on company letterhead to Southern Screw Co., Box 1360, Statesville, N. C. A

Circle 697 on Page 19

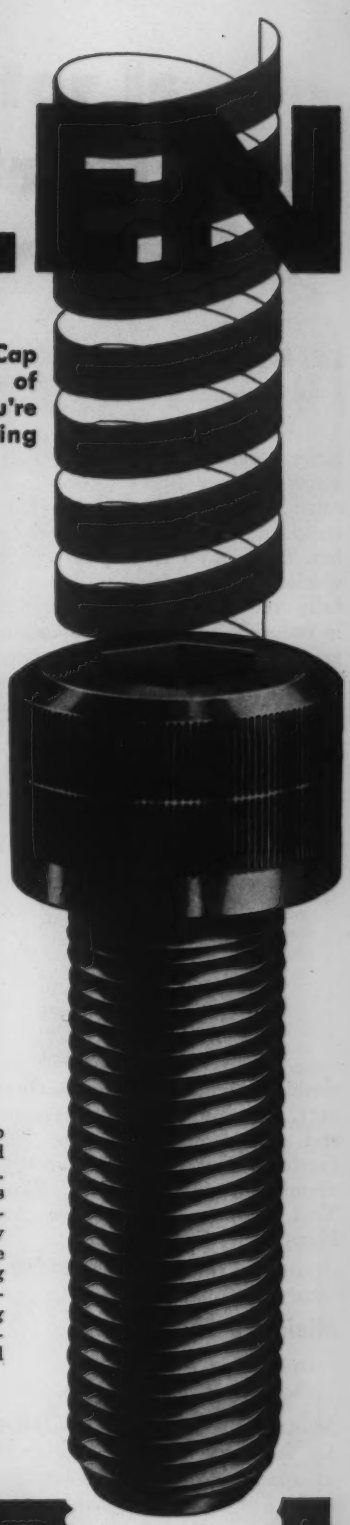
Small-Lot Stampings

Answers to some design questions involving short-run metal stampings are contained in Data Book entitled "Design Suggestion Samples." Drawings and step-by-step procedures for typical stampings involving piercing, bending, and forming conditions are included. Company's production facilities are outlined. 12 pages. Write on letterhead to Dayton Rogers Mfg. Co., 2824 Thirteenth Ave. S., Minneapolis 7, Minn. J

Vibration Isolator

Assistance in the solution of problems of vibration and shock is given in manual on Sorbtex preformed fabric neoprene and rubber pad materials. Use of this non-linear isolator is discussed, and guidance in determining pad thickness for various applications under machinery is included. 40 pages. Write on letterhead to Voss Engineering, Inc., 5649 N. Ravenswood Ave., Chicago 26, Ill. I

ALLEN



The cost of ALLEN Hex-Socket Cap Screws is only a minor fraction of your assembly costs . . . be sure you're getting the timesaving, cost-saving advantages of genuine Allens!

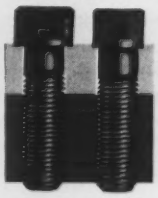
Ever since Allen first produced the hex socket head screw nearly fifty years ago, specifying *genuine* Allens (made by Allen of Hartford) has been a sure way to guarantee dependable threaded fastening.

Only *genuine* Allens have Leader Points that make starting easier, and greatly minimize danger of cross threading. *Genuine* Allens are "pressur-formd" to preserve the long fibers uncut throughout the length of the screw, giving stronger sockets for greater tightening torque.

Write for samples and engineering data. See how *genuine* Allens will make your product better.

ALLEN HEX-SOCKET SCREWS HEAD

Allen's new 1960 Series Socket Head Cap Screws give up to 2½ times more load carrying capacity, without indentation. Head diameter of sizes from ¼" up is now uniformly 1½ times the body diameter—providing more under-the-head bearing surface, and a proportionate increase in clamping force. Write for new Bulletin G-25, with full specifications.



Stocked and sold by leading Industrial Distributors everywhere

ALLEN MANUFACTURING COMPANY
Hartford 1, Connecticut

Circle 522 on Page 19

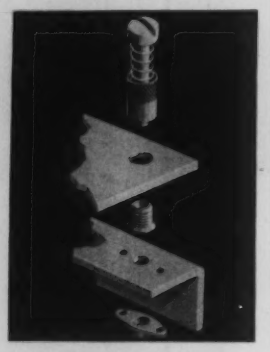
New Parts and Materials

Use Yellow Card, page 19, to obtain more information

Self-Retained Fastener

for electronic packaging

Use of self-retained fastener eliminates possibility of lost or misplaced screws falling into electronic circuitry. Captive screw mates with any standard internally threaded member. Installation is simple, with no special tools required. Fastener is fully retractable, completely flush in unlocked position. It has variable grip range, with ⅛-in. adjustment for different panel thicknesses. Fastener is rigidly mounted. Screw as-



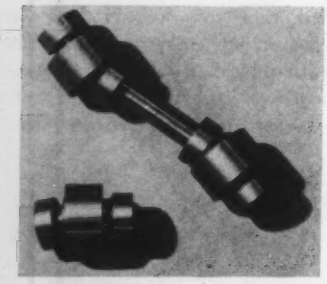
sembly is anodized aluminum (housing), cadmium-plated steel (screw), and passivated stainless steel (spring). Nut retainer is anodized aluminum. **Calinoy Div., Illinois Tool Works,** 12917 Cerise Ave., Hawthorne, Calif. L

Circle 698 on Page 19

Miniature Shaft Joints

in 1/32-in. increments to ½-in. diam bore size

Miniature shaft joints are available for applications where angular misalignment conditions exist, or where a floating shaft is required to compensate for wide parallel and angular misalignment, or both. Shaft joints are suited for power take-off drives from machinery, solenoids, potentiometers, and remote-control



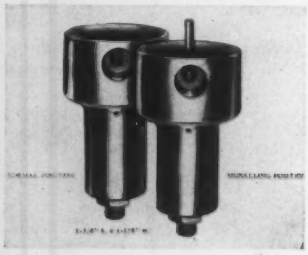
applications. Shaft joints, of stainless steel, assure tight backlash at high speeds and torque. Bore sizes range in 1/32-in. increments to ½-in. diam. Miniature units measure 11/16 in. diam by ⅞ in. long. **Fourdee Inc.,** P. O. Box 6006, Orlando, Fla. O

Circle 699 on Page 19

Indicating Relief Valve

has pin which shows when valve is open

Compact size, variable relief-pressure adjustment, and continued indication of operation, even after pressure has returned to normal, make Demi Tattle-Tale valve suitable for applications where it is important to know if pressure has opened valve. Red anodized indicating pin pops out of valve body at instant valve opens. Pin is easily visible and remains in out position until manually reset. Pressure-adjustment screw on top of bonnet can be furnished for relief settings from 3 to 100 psi. Valve is available with NPT connections



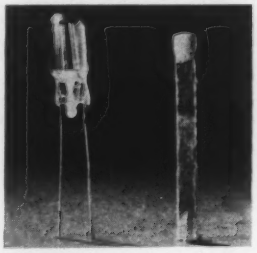
from 1/16 to ¼ in. as well as several tube and fitting sizes. **George W. Dahl Co. Inc.,** 86 Tupelo St., Bristol, R. I. B

Circle 700 on Page 19

Neon Glow Lamp

provides bright, uniform illumination

Neon glow lamp, designated NE-2M and NE-2P, has a smooth, round-end design which utilizes blown bulb for greatly improved end-on appearance and viewing when compared to random-tipped NE-2 or formed-tip NE-2E. Round-end design allows electrodes to be placed close to end of lamp, producing bright, uniform illumination on any plastic facing or cap color used in front of lamp. Both standard brightness (NE-2M), and high brightness (NE-2P) versions are



available. **Miniature Lamp Dept., General Electric Co.,** Nela Park, Cleveland 12, Ohio. F

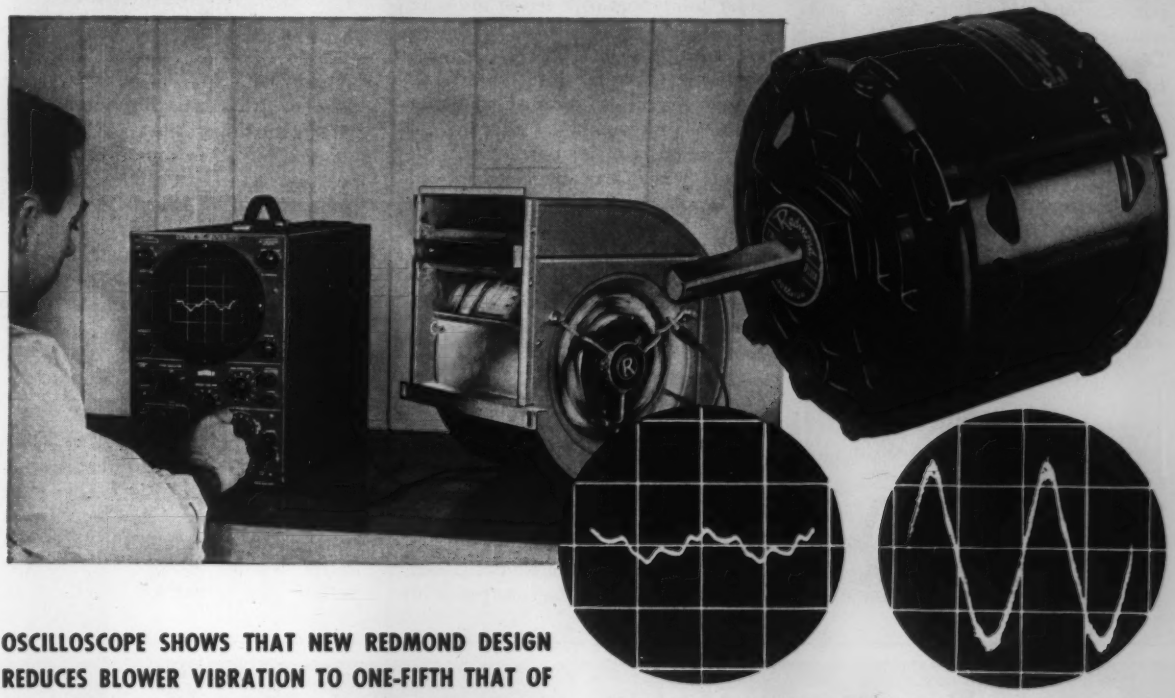
Circle 701 on Page 19

One-Part Adhesive

bonds RTV silicone rubber to metal

EX-B579-1 adhesive provides bonding during room-temperature cure of silicone-rubber compounds. Excellent bonds can be obtained with a variety of RTV silicone rubbers to steel, aluminum, brass, copper, and other metals, as well as glass, po-

New *Redmond* Motor Is Quietest For Direct Drive Blowers



These photographs of the oscilloscope screen show the reduction of vibration in the blower when the Redmond Type AY Micro-Motor is used. The photo at the left shows blower vibration with the Redmond AY; the one at the right shows vibration with a competitive motor.

OSCILLOSCOPE SHOWS THAT NEW REDMOND DESIGN REDUCES BLOWER VIBRATION TO ONE-FIFTH THAT OF UNITS USING CONVENTIONAL SHADED-POLE MOTORS

You can see for yourself on the oscilloscope screen that the Redmond Type AY MicroMotor reduces blower vibration to only one-fifth that of competitive motors running in the blower. Whether you test with vibration testing equipment, a mechanic's stethoscope, or an oscilloscope, you will conclude that the AY is the quietest direct-drive blower motor available. Use it to solve the problem of vibration in your blowers.

The AY Tri-Flux motor is designed and manufactured in every way to give years of trouble-free service and whisper-quiet operation. The Tri-Flux design adds a third flux path, making possible a larger diameter shaded-pole motor that is more efficient and has higher starting and running torque than conventional shaded-pole motors. The positive oil system provides force-feed lubrication. Recirculating the oil assures maximum bearing life.

The new AY is ideal for a wide variety of applications requiring a quiet, economical, quality motor. Redmond sales engineers are skilled technicians whose primary function is applying a motor to your product. Contact us at Owosso, Michigan, and we will have the Redmond sales engineer in your district call you at once. See your telephone book for locations of sales offices in Cincinnati; Cleveland, Dallas; Newark; El Segundo, California; and Oak Park, Illinois.

NEW CATALOG ▶

New 12-page catalog describes and illustrates basic line of Redmond fractional horsepower electric motors, blowers, and special products. Send request for your free copy to Redmond Company, Inc., Owosso, Michigan.

The Standard of Dependability

CC Redmond COMPANY, Inc.

Subsidiary of CONTROLS COMPANY of AMERICA

OWOSSO, MICHIGAN

THE BIG NAME IN SMALL MOTORS

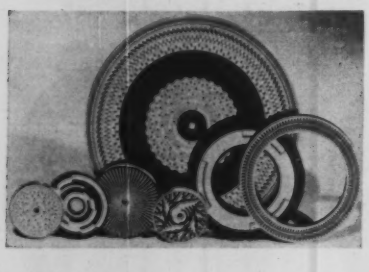
rous ceramics, cured epoxies, phenolics and other resins, synthetic fabrics, and treated Teflon. Applications include potting and insulating of connectors and other components, and aircraft gasketing and sealing. **Hughson Chemical Co., Div., Lord Mfg. Co., Dept. 88A, Erie, Pa.** F

Circle 702 on Page 19

Flush Circuits

with dimensional tolerances of 0.0002 in.

Improved precision flush circuits have durability, high conductivity, fineness of detail, minute size, and micron flushness of inlaid circuit.



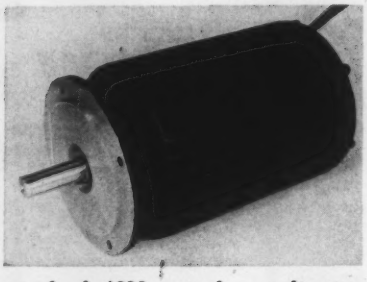
They are suitable for use as commutators, coding discs, emitter discs, switching plates, or for any other application in which smooth, electrical-noisefree brush or wiper action is required. Any desired size and pattern can be provided. Angular tolerances of 5 sec of arc over 360 deg can be held, and dimensional tolerances of 0.0002 in. are achieved. Circuits are flush to less than 1 micron with finish of better than 5 microinches. Flatness of 0.001 in. per in. is guaranteed. All metals which can be electroplated are available in any combination desired. Variety of surface resins is available. Most plastics, including Mylar, and metals can be used as base materials. **Scientific Components Inc.**, 30 S. Salsipuedes St., Santa Barbara, Calif. L

Circle 703 on Page 19

Miniature Motor

1½-hp unit has 3-in. diam

Miniaturized 1½-hp, ten-pole, 200-v, 400-cycle motor is designated Model 38BG3. It has output-shaft



speed of 4600 rpm for application on a centrifugal blower. Unit is designed for continuous duty and measures 3 in. in diam. **Electro Products Div., Western Gear Corp.**, 132 W. Colorado Blvd., Pasadena, Calif. L

Circle 704 on Page 19

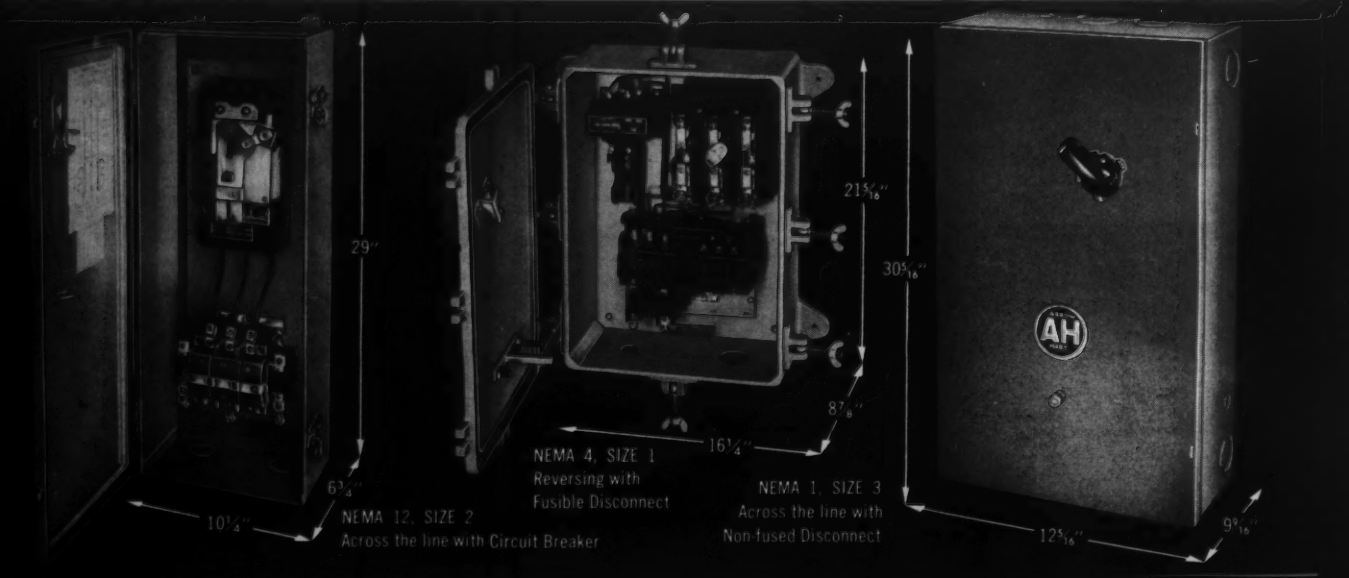
Teflon Etchant

permits bonding of Teflon to itself and other materials

Activated form of sodium in solution, called Tetra-Etch, reacts with Teflon to form a carbonaceous film on treated surface. Film then serves as a means of anchoring adhesives to the Teflon. Compound is compatible with a variety of adhesives,

ARROW AH HART

Announcing: A COMPLETE LINE OF COMBINATION STARTERS UP TO 100 HP, 440 VOLTS AC NEMA SIZES 0, 1, 2 and new sizes 3 and 4



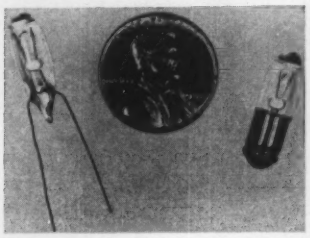
including epoxies, phenol formaldehydes, and most rubber and silicone types. Treatment time ranges from about 5 sec to 1 min, depending upon type of application and conditions. Resulting peel strength with typical epoxy adhesive runs from about 17 lb per in. on smooth Teflon to 35 lb per in. on corrugated ribbon. W. L. Gore & Associates Inc., 487 Papermill Rd., Newark, Del. C

Circle 705 on Page 19

Subminiature Lamp

for computer use has long life

Subminiature incandescent lamp, No. 4, is a 2.5-v, 400-ma lamp less than 1/4 in. in diam and 13/16 in. long (based). Unit is available for computer use as a light source in a photoelectric readout application, and is suitable also as a bright-light, direct end-on-viewed readout indicator. T-1 3/4 high-magnification bulb concentrates 1/4-in. spot pattern 3/8 in. in front of lamp for maximum read-through efficiency. Lamp is available with either brass, midget snap-in base for simple front replacement, or as a wire lamp suitable for soldering or welding directly into a computer circuit. Lamp, which has long life, utilizes a single coil C-2R filament. Tung-Sol Electric Inc., Dept. A, 1 Summer Ave., Newark 4, N. J. D

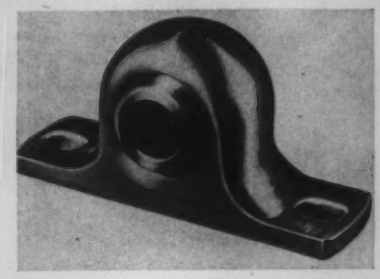


Circle 706 on Page 19

Self-Aligning Pillow Block

has oil-impregnated bronze bearing

Lube-Align pillow block is designed for applications where standard Oilite bearing in a flexible mount is required. It relieves undue stress on rotating shaft and bearing through application of ball-joint principle. Pillow block combines



self-alignment for correction of variations in assembly with oil-impregnated bronze bearing nested in an aluminum die casting. Unit is available in shaft sizes of 1/2, 5/8, and 3/4 in. Bronze Bearings Inc., 3832 N. Cicero Ave., Chicago, Ill. J

Circle 707 on Page 19

Liquid Spring

produces 40,000-lb force on 1/4-in. stroke

Model 2040 liquid spring is a self-contained unit only 2 1/2 in. in diam and 5 in. long. It produces 40,000-lb force on 1/4-in. stroke. In-

MOTOR CONTROLS

New NEW WEATHERPROOF and EXPLOSIONPROOF ENCLOSURES WEIGH ONE-HALF AS MUCH AS CONVENTIONAL BOXES

Offering Weatherproof and Explosionproof enclosures of strong, cast aluminum, *one-half the weight of old-style cast iron boxes.* Choice of fused or unfused Disconnect Switch or Circuit Breakers.

ENCLOSURES FOR EVERY USE:

- General Purpose – NEMA TYPE 1
- Weatherproof – NEMA TYPE 4
- Explosionproof – NEMA TYPES 7 and 9
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AVAILABLE:

- Non-Reversing, Reversing and Two-Speed Types
- In NEMA SIZES 0 through 4
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"RIGHT ANGLE" DESIGN STARTERS:

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- Large, Long-Life Contacts • Easy Maintenance Proved Dependability

Write today for engineering details on Arrow-Hart's complete lines of Combination Starters to: The Arrow-Hart & Hegeman Electric Co., Dept. MD, 103 Hawthorn St., Hartford 6, Conn.

ARROW-HART of HARTFORD

Quality since 1890

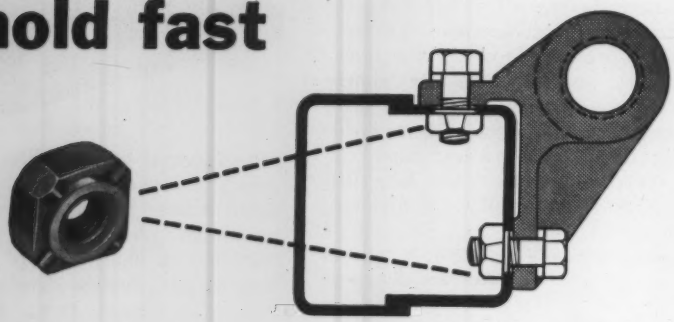
MOTOR CONTROLS • ENCLOSED SWITCHES • APPLIANCE SWITCHES • WIRING DEVICES

Circle 524 on Page 19

MIDLAND

WELDING NUTS

hold fast



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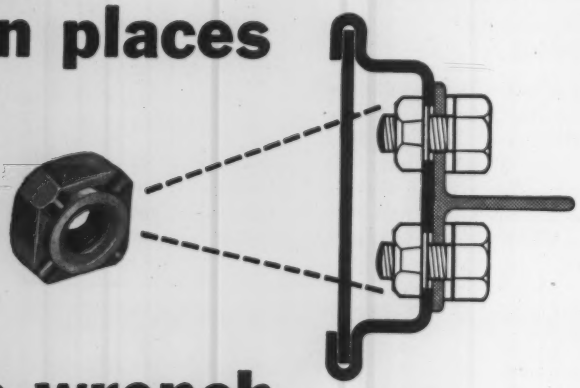
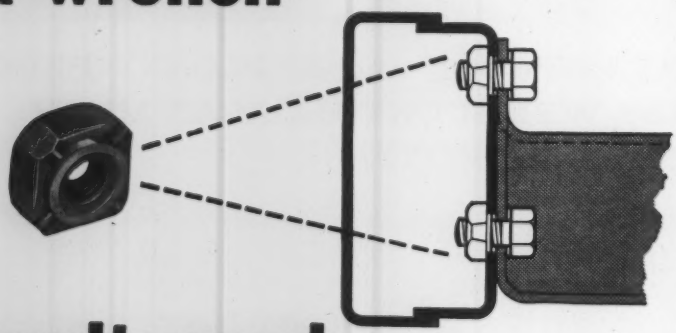


a wrench



can't reach

Looking for cost and time-saving tips? Send for the free booklet showing you how to "Save With Midland Welding Nuts."

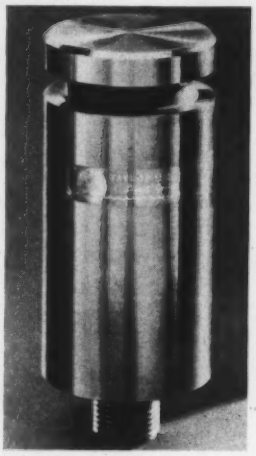
MFR MIDLAND-ROSS CORPORATION

OWOSSO DIVISION • OWOSSO, MICHIGAN

MIDLAND WELD NUT

Circle 525 on Page 19

terior shock-absorber action can be added without changing over-all dimensions, making combination spring and shock absorber. Shock-absorbing force is available up to 60,000 lb (15,000 in.-lb energy absorption). Spring rate is 120,000 lb per inch of deflection. Mounting method is a 1-in. stud; other mountings, such as pin eyes, clev-



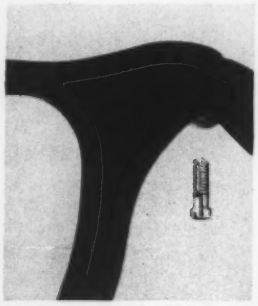
ises, or trunnions, are available. **Taylor Devices Inc.**, 188 Main St., North Tonawanda, N. Y. N

Circle 708 on Page 19

Subminiature Screw

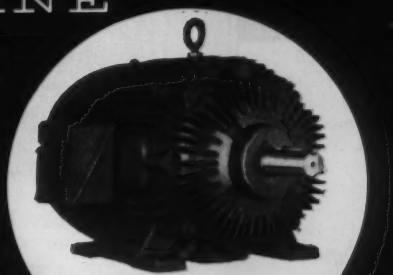
self-locking unit has high reusability

Subminiature screw permits finger-pressure insertion and eliminates abraded locking materials. Other features include high torsional



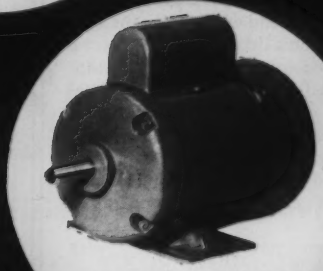
strength and gradual torque build-up to resist breaking, and minimum thread engagement for positive locking action. Screw is vibration and shock resistant, is removable, and has high reusability. Designed originally for use in eyeglasses, it has

MOTORS DESIGNED WITH MACHINE TOOLS IN MIND...

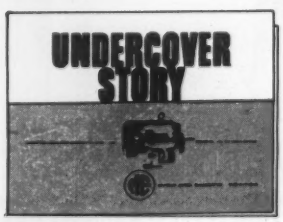


INTEGRAL H.P. MOTOR
TOTALLY ENCLOSED
FAN COOLED

DIRECT CURRENT
MOTOR



FRACTIONAL H.P. MOTOR
TOTALLY ENCLOSED
FAN COOLED



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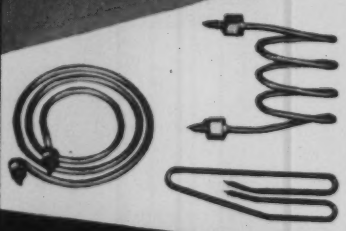
MARATHON ELECTRIC

Home Office and Factory, Wausau, Wis. Factories at Erie, Pa. and Earlville, Ill.
Sales Offices in Principal Cities

VULCAN TUBULAR HEATERS



In the best of shapes

Here are just a few of the many shapes to which Vulcan Electric Tubular Heaters are formed. They are ideal for immersion in liquids, soft metals or molten salts. Straight, tubular heaters are easily clamped to metal surfaces or inserted in machined grooves. Vulcan Tubulars are easily cast into aluminum, iron or other metals. They can also be furnished with flattened surface for even more efficient heat transfer.

Vulcan Tubular Heaters are especially useful when you want a lot of heat in a little space. You have a wide choice of sizes — 10″ to 148″ (special — shorter or longer); diameters — .250″, .280″, .333″, .450″; wattage — 10 to 10,000 (or higher); voltage — standard 120 or 240, special 6 to 480 (or higher); sheaths — copper, steel, high temperature alloys.

Solve your hot problems with *Vulcan Versatility* in electric heat. Send coupon for catalog and prices.

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Soldering and Branding Irons • Solder and Glue Pots

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6 Holten Street, Danvers, Mass.
Please send me catalog and price information on Vulcan Electric Heaters.

Name & Title.....
Company.....
Street & No.....
City & State.....

Circle 527 on Page 19

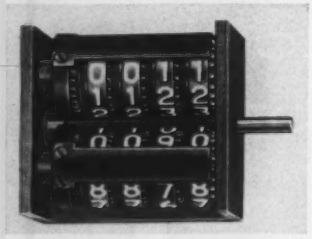
wide usage in instrument applications and in all areas where miniature self-locking screws are required. Long-Lok Corp., 2601 Colorado Ave., Santa Monica, Calif. L

Circle 709 on Page 19

Dual-Bank Counter

provides plus and minus readings

Model Y dual-tank counters are for use in navigation and tracking equipment, machine tools, and all digital-readout equipment where plus and minus readings are needed. Counters are built with nylon wheels and pinions to reduce



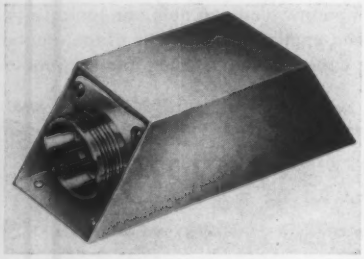
torque and give lower moment of inertia, higher speed, and longer life. Counter is available in right or left-hand drive, clockwise or counterclockwise rotation, and with three, four, or five digits. One revolution of shaft equals one revolution of first wheel or ten counts to one revolution of shaft. Unit operates over temperature range of −55 to +75 C. Durant Mfg Co., 1933 N. Buffum St., Milwaukee 1, Wis. K

Circle 710 on Page 19

Servo-Valve Amplifier

for missile and aircraft guidance systems

Small, lightweight servo-valve amplifier, designed to meet military specifications, is only 4 in. long,



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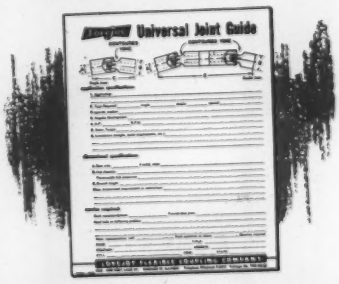

Request handy Universal Joint Guide, Form 820F, and Bulletin 820.

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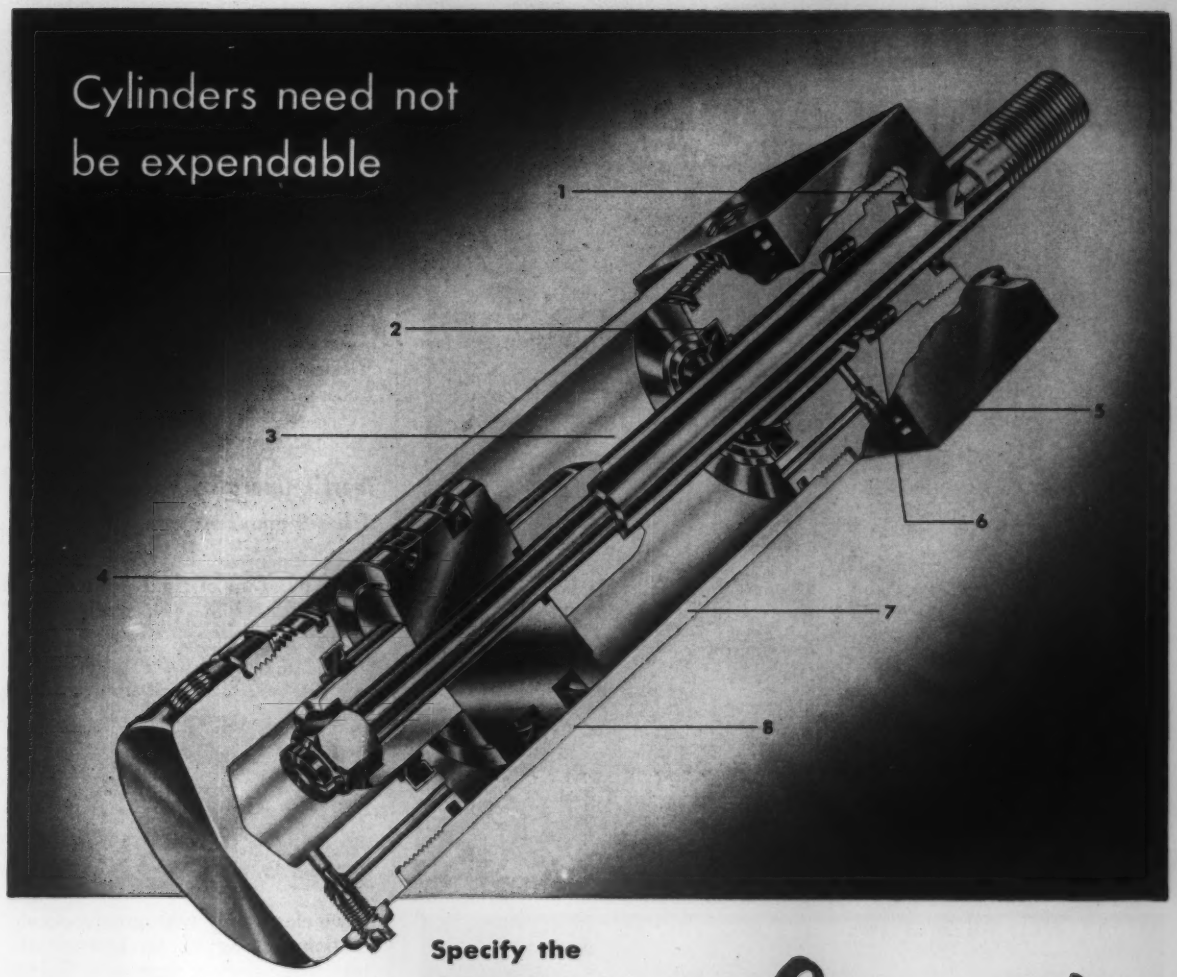
Circle 528 on Page 19



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T-J Spacemaker

for longer, more efficient cylinder service

You too—can reduce replacement expenditures—lower maintenance costs with the T-J Spacemaker cylinder line. Designed and engineered for ruggedness, and accuracy of operation, the Spacemaker assures longer, uninterrupted operation.

The T-J Spacemaker eliminates tie-rods, gives greater strength, saves space . . . and reduces costs in all push-pull operations. Immediate delivery in a complete range of styles and capacities . . . air or oil. Write for Bulletin SM 155-4, today. The Tomkins-Johnson Company, Jackson, Michigan.

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1. METAL PISTON ROD SCRAPER—protects rod packing, cylinder bore and rod surface by removing all foreign particles.
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6. PILOTED PACKING GLAND with extra long bearing for additional strength and support to piston rod.
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8. STREAMLINED DESIGN . . . operating pressures to 200 PSI, air; 1,000 PSI oil, non-shock.

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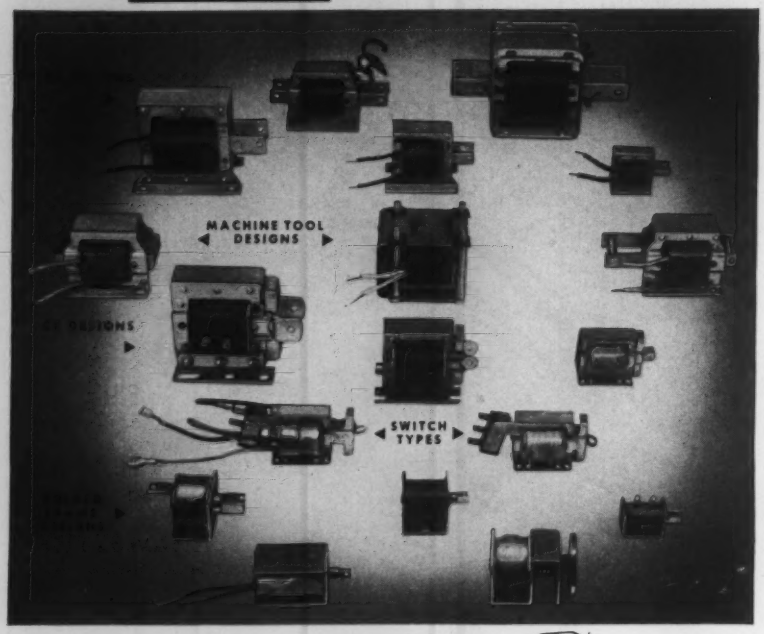
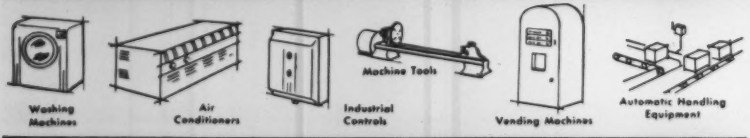
Circle 529 on Page 19

SOLENOIDS
for *every* application





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A COMPLETE LINE OF CUSTOM-DESIGNED SOLENOIDS . . . Available from stock or designed and constructed to meet your specific requirements. Twenty-four hour delivery from date of order on stock items. Prompt estimate on specials upon receipt of b/p or specifications. Expert engineering assistance available.

LENGTHEN PRODUCT LIFE . . . The quality parts that go into a DORMEYER solenoid and their expert fabrication account for its rugged dependability. In turn, this long-lasting reliability increases product service life.

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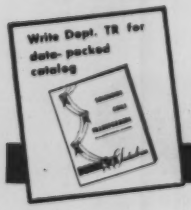
REDUCE PRODUCTION PROBLEMS . . . Made to your specifications, DORMEYER solenoids feature close-tolerance component parts that eliminate many problems in product assembly. And their ruggedness withstands handling.



Dormeyer Solenoids are made for all commercial voltages and frequencies. Standard sizes from 1⅛" x 1⅛" to 3" x 3" . . . stroke lengths fractional to 2" . . . pull and/or push capacities to 35 lbs. Larger sizes made to specifications.

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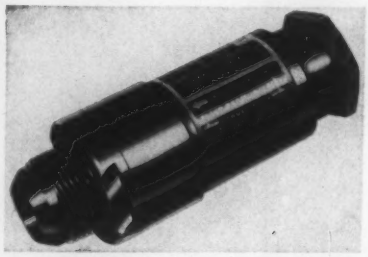
$1\frac{1}{2}$ in. square, and weighs 8 oz. Unit provides proportional control of hydraulic transfer valves in missile and aircraft guidance systems. It combines inherent low drift, reliability, and ruggedness of magnetic amplifiers with compactness of silicon semiconductors and resistors. Output is 8 ma dc push-pull into two 1400-ohm loads; control signal is 0.5 to 2 v dc into 300-ohm load. **Electric Products Div., Vickers Inc.,** 1815 Locust St., St. Louis 3, Mo. I

Circle 711 on Page 19

Inertia-Operated Valve

has 9 gpm flow rate

Inertia-operated shut-off valve prevents build-up of fluid pressures in liquid-fuel system. Normally open,



valve closes only with gravity-acceleration loading; as acceleration diminishes, device reopens. Valve, No. 35-2064-000, is supplied in any line size and is lightweight. Design calls for flow rate of 9 gpm with maximum pressure drop of 0.5 psi. **Aero Supply Mfg. Co. Inc.,** Corry, Pa. F

Circle 712 on Page 19

Ball Bearings

are high-carbon steel

Utility ball bearings allow large price reductions compared to similar sized precision units. Most ef-

THE USES OF VULCANIZED FIBRE'S INHERENT TOUGHNESS

by Earl A. Russell, Chief Engineer, Spaulding Fibre Company, Inc.

The toughness of Vulcanized Fibre often contributes uniquely to meeting crucial requirements of an application as well as to making possible low cost fabrication. For example a vulcanized fibre kickback plate in a bowling alley makes effective use of its built-in toughness while in an automobile starter switch the toughness of fibre permits swaging a supporting bushing to fit the switch case.

What die casting does in reducing the cost of odd shaped parts in metals, swaging does with vulcanized fibre. In addition to being tough enough to readily withstand punching operations, it is also sufficiently plastic to permit swaging to shape. In this particular swaging operation the fibre is compressed in some areas and flowed into raised areas to form a shank fitting into the hole and a shoulder fitting the contour of the starter switch case (Fig. 1).

In the assembly the sturdy switch contacts are economically mounted and fully insulated with vulcanized fibre, taking advantage of the toughness of the fibre parts to provide adequate support against the impact of entering switch contacts.

It may be noted further that combined with the toughness to withstand punching and the plasticity to permit swaging into low cost parts, vulcanized fibre provides the required electrical insulation.

In the bowling alley application (Fig. 2) wood could not take the beating from the pounding blows of the pins as they smash against the partitions that separate the alleys. For protection of the wooden partition, the toughness of vulcanized fibre is required to withstand the repeated blows from the pins. At the same time the fibre must be sufficiently plastic to avoid damaging the pins yet resilient enough to provide acceptable rebound for desirable pin action.

Fibre performs these unusual functions through years of service at surprisingly low cost.

In railroad track insulation, athletic protective parts, gaskets for high pressure systems, switch parts, electric motor parts and formed parts for many applications, the toughness of fibre combines with other important properties to provide a simple part which performs two or more functions with good results and low cost.

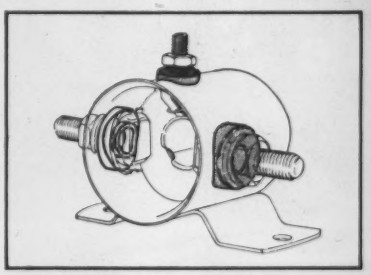


FIGURE 1. A complex shape difficult to machine by ordinary methods, this vulcanized fibre bushing is swaged and punched in one operation to produce a low cost part to meet strict requirements of toughness. Supporting heavy duty contacts under repeated shock loads, the bushing also insulates the contacts against the surrounding case.

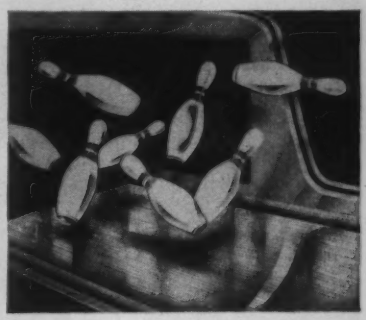


FIGURE 2. Tough vulcanized fibre kickback plate absorbs the impact of the flying pin without damage to the pin or the partition. The rebound action, so necessary to top scores, is possible because of the resiliency of the fibre.

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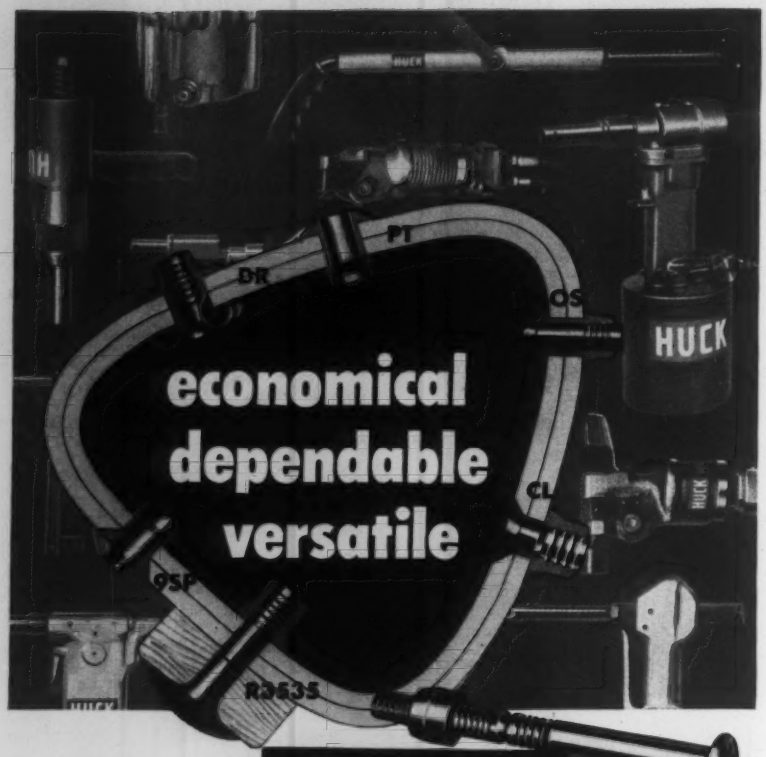

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High strength, shear and tension.

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Low cost blind fastener.

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Grommet type blind fastener.

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Broad grip, broad bearing.

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High strength blind fastener.

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Nearly two thirds of any fastening operation cost is in labor.

The Huck fastening system is designed for time saving, uniform installation with greater fastener dependability.

Huck pneumatic, hydraulic or manual installation tools are compact, light and easy to operate. Even with unskilled operators, installation rates of 25 to 30 fasteners per minute are normal.

There is a Huck fastener for every need—high shear or tension, self sealing, broad bearing, hole broaching, hollow or pin retaining, blind or regular style — aluminum, steel or high temperature metals—headstyles, diameters and lengths to fit your job.

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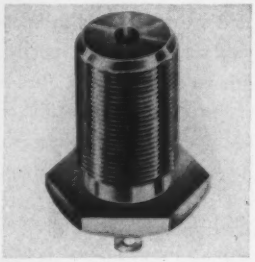
fective use of the high-carbon steel bearings is as substitute for precision bearings where such bearings are not needed. **Global Ball & Bearing Co. Inc.**, 1847 Highland Ave., New Hyde Park, N. Y. D

Circle 713 on Page 19

Pressure Switches

are small in size and lightweight

Hermetically sealed model 419 switches electrical circuits in response to pressure changes in hydraulic fluids, fuels, or other gases or liquids. Since switch is isolated from pressure media, it can be used to detect leaks in fuel, pneumatic,



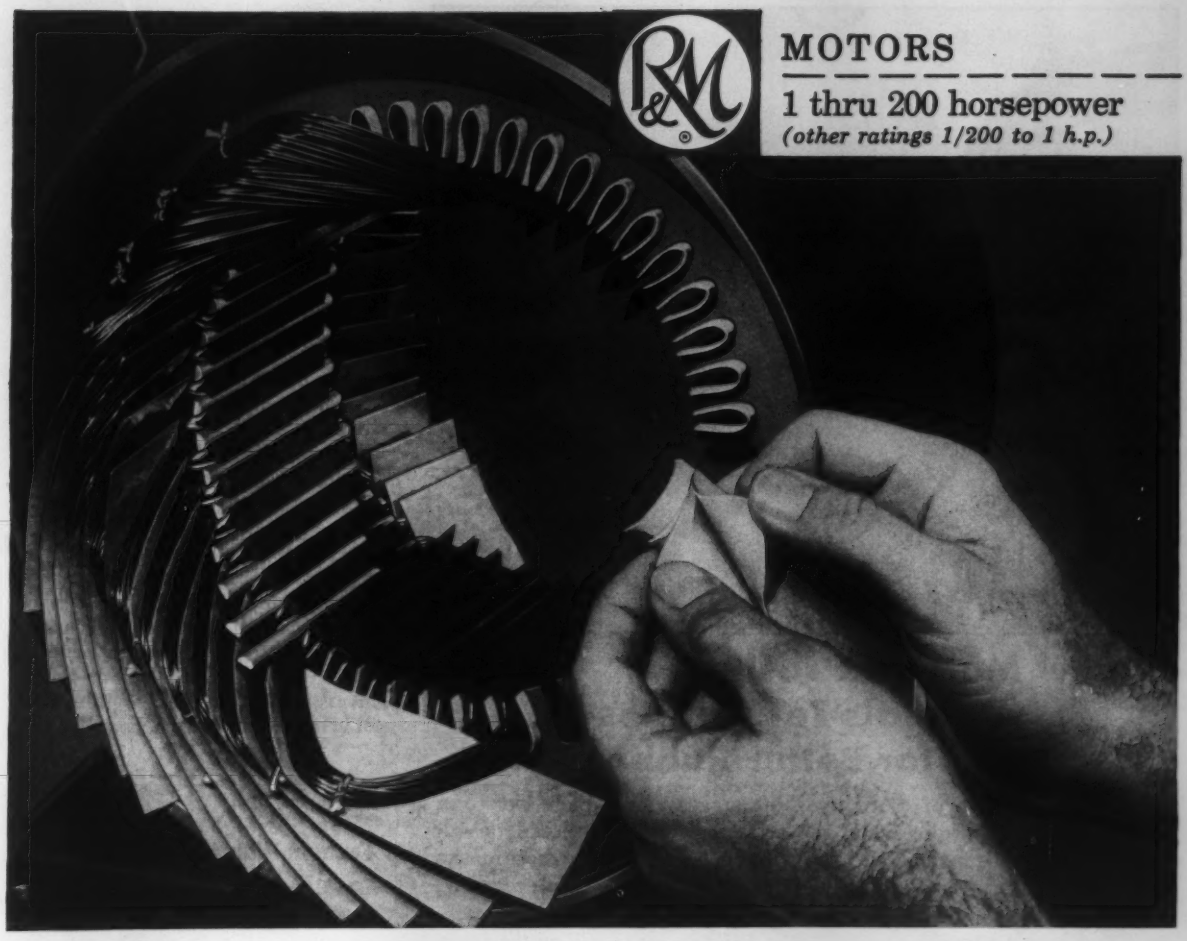
or hydraulic systems of aircraft and missiles, as a warning indicator in ground check-out systems, to monitor industrial processes where pressure leakages present a safety or health hazard, or as a conventional pressure switch. Available in three design configurations, switches have small size and light weight to permit mounting directly on pressure fittings or building into pressure-fitting hardware. Pressure range is 1 to 500 psig, and operating temperature range is −65 to +165 F. Units meet MIL-E-005272B, Procedure 1, specifications for vibration level, shock, acceleration, and humidity. **Bourns Inc.**, P. O. Box 2112, Riverside, Calif. L

Circle 714 on Page 19

Self-Locking Fasteners

of aluminum alloy attach directly to structure

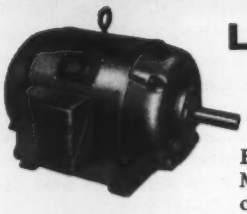
Two one-piece, right-angle, self-locking fasteners, for medium to light loads, are suitable for attaching instrument panels, shock-mounting delicate equipment in packaging containers, and mounting tubing and wiring harnesses. Fasteners



MOTORS

1 thru 200 horsepower

(other ratings 1/200 to 1 h.p.)

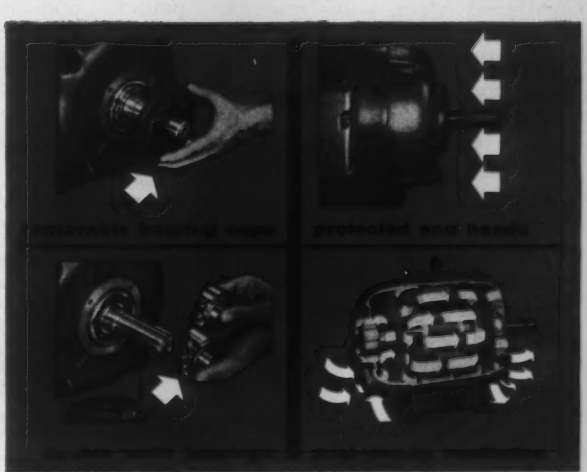


Locked-In, Laminated Insulation

Insures Longer Life for your R&M Motor!

Each slot-cell in your ROBBINS & MYERS motor grips a triple layer of insulation around the windings. Installing these insulation "sandwiches" is a time-consuming job but it pays off in long motor life. Mylar* laminated to rag paper is first inserted. Reinforced edges prevent slipping and scuffing. The dielectric qualities of Mylar* (8 times that of conventional insulation) combined with its resistance to tearing and aging affords permanent protection; the rag paper backing acts as a cushion against abrasion and punctures. A second layer of insulation is inserted to eliminate the danger of weak spots. The wire coil, coated with triple resin insulation, is inserted and a third layer of insulation is placed over it. Insulation is placed between the coil ends, wedges are inserted to hold the coil firmly in place and the stator is twice dipped in special insulating varnish and baked after each dip, thus forming an armor-like coating. Coil ends are coated with a moisture-proof sealer. This is insulation you can trust, yet it's yours at standard prices! For more details write for Bulletin 520 MD

**DuPont registered trademark*



ROBBINS & MYERS, INC.

motors, household fans, Propellair industrial fans, hoists, Moyno industrial pumps

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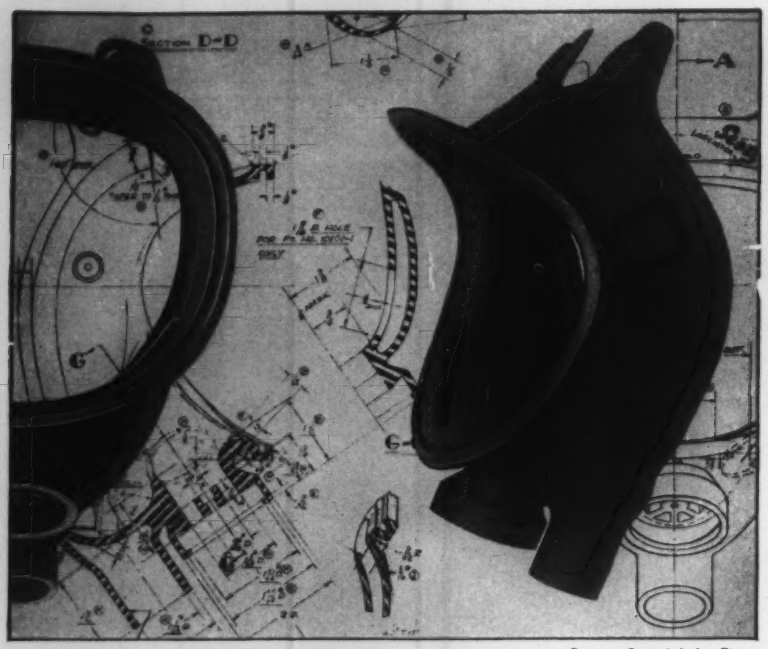
Circle 533 on Page 19



Courtesy Scott Aviation Corp.

New Molded Profile Reveals Techniques for Better Rubber Specs

In the early stage of planning and design, it was questionable whether this face mask could be molded in rubber—in one piece—practically, yet economically . . . and here's why.

It calls for an ingeniously designed and machined mold to provide for facial contours, air inlets and outlets, undercuts, feathered edges, valve mounts, fastenings, etc.—one of the hardest-to-fill cavities ever encountered. Also, the rubber must be compounded to flow freely inside this complicated form and still maintain its knitting qualities. How was this accomplished?

While the mask was still in the design stage the customer realized the importance of consulting a rubber specialist. From this conference came an exchange of suggestions which led to a practical and functional design that permits molding these masks with unusual speed and economy. Here's the idea.

While a job is still on the drawing board consult with rubber specialists. Suggestions can often be made to eliminate high tooling costs or high priced compounds. End results give you better rubber parts, better performance and lowest cost. Regardless of how simple or complex your rubber needs may be call Continental—specialists since 1903.

Engineering catalog.

In addition to custom-made parts, Continental offers an extensive line of standard grommets, bushings, bumpers, rings and extruded shapes. Hundreds of these are shown in the No. 100 Engineering Catalog. Send for a copy or refer to it in Sweet's Catalog for Product Designers.

Another achievement in **RUBBER**
engineered by **CONTINENTAL**

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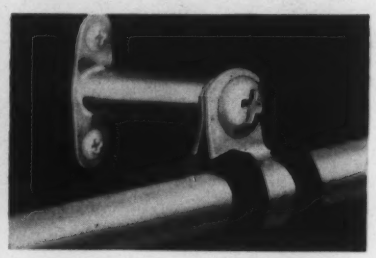


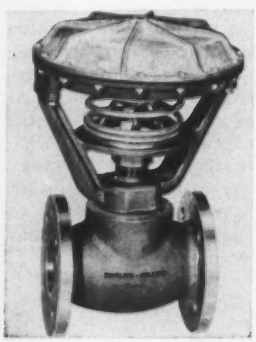
incorporate self-locking device and mounting bracket in one unit, and attach directly to structure without separate mounting bracket. Because they are forgings or impact extrusions, fasteners are extremely strong. Made of aluminum alloy, they are light in weight. Strength and rigidity permit wide spacing to reduce structural weight. Fasteners will not corrode, are nonmagnetic, simplify bonding problems, and resist high vibration and shock. Many configurations are available in lengths from 0 to 3 in. in 0.2-in. increments. **Western Sky Industries,** 21301 Cloud Way, Hayward, Calif. M

Circle 715 on Page 19

Vacuum Valves

seal and hold vacuum to within 0.5 in. Hg absolute

Diaphragm-operated vacuum valves are for use where high flow rates and positive sealing are of primary importance. Capable of sealing and holding vacuum to within 0.5 in. Hg absolute for an indefinite period of time, valves feature resilient, synthetic O-ring seat seals and direct metal-to-metal seat stops to assure positive seal without O-ring deterioration in heavy-duty service. Valves are available in flange or screw-mounted two-way types, and in sizes to 3 in. NPT. Full inter-



HANDY & HARMAN SILVER BRAZING
Permits Manufacturer to Guarantee Underwater Air Regulator For Life

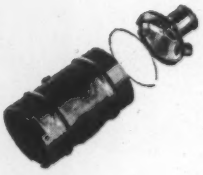
Perhaps the most vital component of a skin diver's equipment, this Viking Air Regulator, manufactured by Christensen Tool & Engineering Company, Norwalk, Connecticut, is structurally guaranteed for life. It must, under all conditions, be absolutely leaktight. The manufacturer's guarantee is a relatively recent achievement—through the high-strength help of silver alloy brazing with Handy & Harman EASY-FLO 45 and HANDY FLUX.

Over and above the unreserved dependability of brazed joints, the brazing method itself has saved the company considerable time, money and material in the production of the Viking Air Regulator. Brazing's simplicity is interestingly illustrated in this case by this company's requirement that assemblers and testers of the Viking must be skin divers themselves.

Almost invariably, silver brazing effects economies and brings advantages to whatever part, product or assembly it is applied. True, air regulators are few and far between, but the point is that they are *metal products, made of a number of different metal components.*

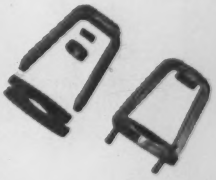
And that's the phrase that covers brazing's great adaptability. To give you a good idea of how you can put brazing to work, we'd like to send you Bulletin 20—it covers the basics of brazing and it may very easily solve your metal-joining problems. Handy & Harman, 82 Fulton Street, New York 38, N. Y.

Here, in "serial" form is how the guarantee is "brazed" into the Viking:

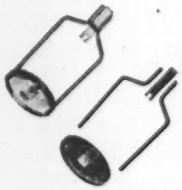


1. TANK HOUSING—Initially, this component was mechanically joined and made "airtight" by means of sealants. Now, brazing eliminates 8 holes, 4 tapping operations, 4 screws and 3 assembly operations.

5. Shown here are the finished Viking components before and after assembling. —Brazing by Specialty Brazing Laboratories, Riverside, Connecticut.



3. YOKE—This is assembled from stampings instead of castings, which were previously used. With brazing, no secondary finishing operations are required. Further, the part is stronger and lighter, and savings on material and labor on this component alone add up to 28%.



Your No. 1 Source of Supply and Authority on Brazing Alloys

2. FORK ASSEMBLY—There are five separate brazed joints, done with hand torch and hand-fed wire. Brazing eliminates one tapped hole, a lock washer and a spacer, plus the fact that positive alignment is now guaranteed.

HH

HANDY & HARMAN

General Offices: 82 Fulton St., New York 38, N. Y.

DISTRIBUTORS IN PRINCIPAL CITIES

4. PISTON—This is the most important single element of the Viking. It regulates flow of oxygen from cylinder to mouthpiece; from 300 lbs. pressure to normal breathing. Without brazing, this part could not be made.

COMING IN NOVEMBER! *New Handy & Harman Brazing Correspondence Course. Simple self-study data on all phases of brazing. Send for details to Dept. BC.*

'DIAMOND H'
SERIES W

General Purpose Relays

MEASURE ONLY:
1½" x 1½" x 1⅛"

BUT CARRY:
to 25 A. resistive at 115-230 V., A. C.; 1 h.p., 125 V., 2 h.p., 250 V., A.C.; D. C. and other higher ratings on request.

CONTACTS:
DPDT, Double Break-Double Make (Form Z). Special arrangements and sequence on request.

MOUNTINGS:
Socket, panel and sidewall arrangements standard; others to meet special needs.

"Diamond H" engineers are prepared to work out variations of these rugged, dependable relays to meet your specific requirements in such applications as **automation controls, appliances and air conditioning equipment,** or what you will. Just ask.

THE
HART
MANUFACTURING COMPANY
118 Bartholomew Avenue
Hartford, Conn.
Phone Jackson 5-3491

Circle 536 on Page 19

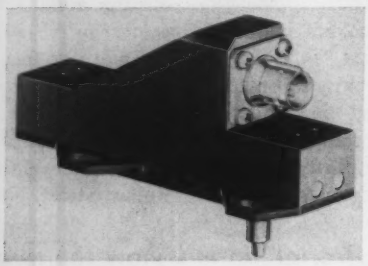
changeability of parts simplifies in-service maintenance. Valves are actuated by suitable pneumatic or electropneumatic pilot, cycle control unit, or remote manual control. **Sinclair-Collins Valve Co.**, 454 Morgan Ave., Akron 11, Ohio. F

Circle 716 on Page 19

Precision Potentiometers

side-actuated types have long life

Two types of side-actuated precision potentiometers are extremely suitable for control surface feedbacks on missiles because of long life and low noise characteristics when sub-



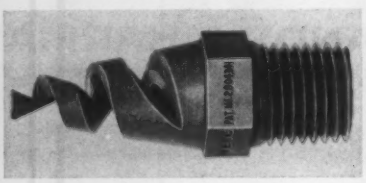
jected to high-frequency dithering. Type 3063 offers stroke length of 1.89 in. and Type 3064, of 2.85 in. They display outstanding shock, acceleration, and vibration resistance in excess of 50 g without opening or discontinuity. Other characteristics are virtually infinite resolution and independent linearity better than ±0.5 per cent. **Markite Products Corp.**, 155 Waverly Place, New York 14, N. Y. D

Circle 717 on Page 19

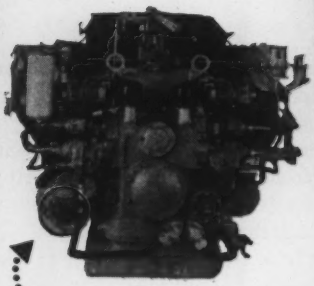
Plastic Nozzles

are nonclogging and long wearing

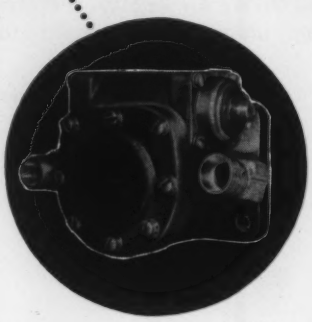
PVC nozzles are for use wherever a nonmetallic, corrosionproof nozzle is required. Made from one piece of plastic in a spiral design, nozzles are nonclogging and long wearing. They are available in 28 models with wide or narrow angle, full or



FOR FUEL BOOST SERVICE
on Continental Motors



it's VIKING PUMPS



WHY? BECAUSE...

- Viking Pumps meet all of the requirements of the custom built application.
- Viking Pumps' positive "gear-within-a-gear construction is always dependable.
- Viking Pumps have uniformly high quality parts and workmanship.

CONTINENTAL MOTORS, INC., Muskegon, Michigan, builders of engines for industry and the armed forces, chose Viking Pumps as standard equipment for fuel boost service. They tested many other pumps, but Vikings met their rigid requirements best. Thousands of our pumps are now serving on Continental engines — solid proof that they're giving satisfaction.

You, too, may well look to Viking Pumps for the answer, if you have a problem in fuel boost service, bearing lubrication, transfer service, hydraulic actuation, etc. Standard or custom built pumps in sizes from ⅔ to 1050 G.P.M. are available.

For information, send for folder 409H today!

VIKING PUMP CO.

Cedar Falls, Iowa, U. S. A.
In Canada, it's "ROTO-KING" Pumps
See Our Catalog in Sweet's Product Design File

Circle 537 on Page 19

to protect tubing, threaded or machined parts in process, storage and transit

THERE'S NO BETTER WAY THAN THE CAPLUG* WAY

Over 500 sizes in a dozen different styles carried in stock to meet almost any closure need you can name

* Made of tough, flexible Polyethylene, Caplugs are easy to apply and a cinch to remove. Especially kind to threads and polished surfaces, they won't chip, break, shred or collapse.

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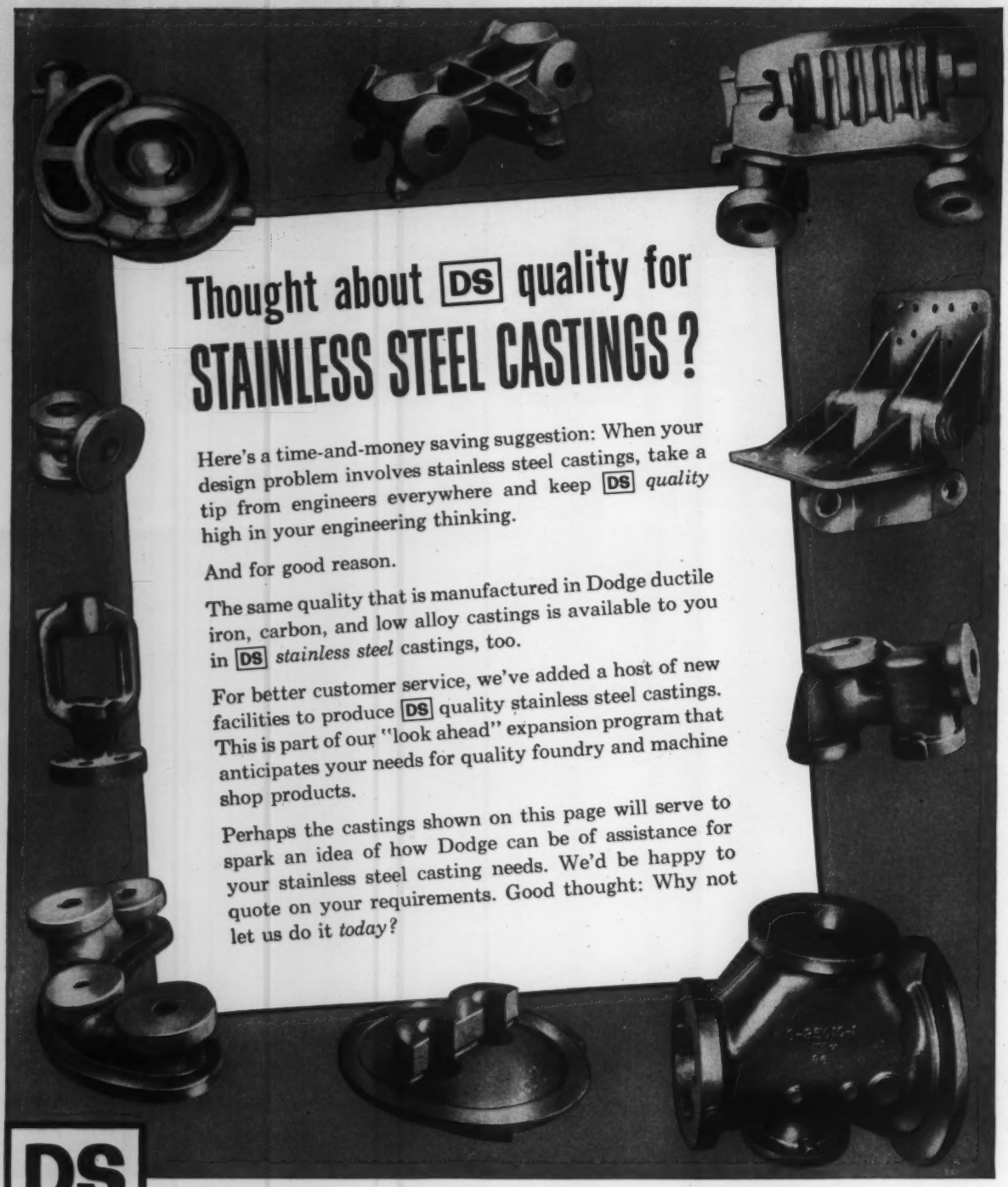
Circle 538 on Page 19



Thought about DS quality for STAINLESS STEEL CASTINGS?

Here's a time-and-money saving suggestion: When your design problem involves stainless steel castings, take a tip from engineers everywhere and keep DS *quality* high in your engineering thinking.

And for good reason.

The same quality that is manufactured in Dodge ductile iron, carbon, and low alloy castings is available to you in DS *stainless steel* castings, too.

For better customer service, we've added a host of new facilities to produce DS quality stainless steel castings. This is part of our "look ahead" expansion program that anticipates your needs for quality foundry and machine shop products.

Perhaps the castings shown on this page will serve to spark an idea of how Dodge can be of assistance for your stainless steel casting needs. We'd be happy to quote on your requirements. Good thought: Why not let us do it *today*?

DS DODGE PRODUCTS

DODGE STEEL COMPANY

6501 State Road • **Philadelphia 35, Pa.** • DEvonshire 2-2200

Stainless

THE MOST IMPORTANT ALLOY IN A STEEL CASTING IS QUALITY

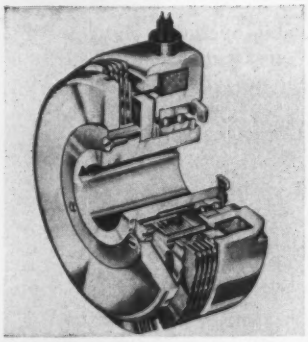
hollow cone, and seven flow rates from 2 to 70 gpm. **Bete Fog Nozzle Inc.**, 309 Wells St., Greenfield, Mass. B

Circle 718 on Page 19

Electromagnetic Clutch

is wet-type unit
available in eight sizes

Electromagnetic clutch, Model KA, is for use in semiautomatic and fully automatic process machines, program and tracer machines. The wet-type clutch permits an almost unlimited variety of spindle speeds, feed and traverse movements, and directional changes. Compact design permits as many as 40 clutches



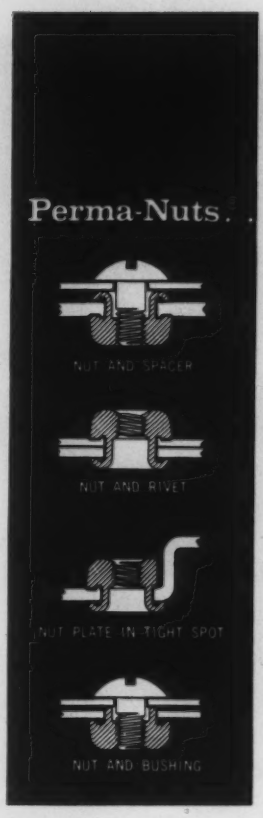
to be incorporated in a single machine with mounting on motor shaft or countershaft. Standard coils are 90-v dc, with other voltage coils available for special requirements. Available in eight sizes from 3.3 to 11.5-in. diam, clutch offers capacity range of ¼ to 34½ hp at 100 rpm, with maximum torque ratings of 14.5 to 1812 lb-ft. **Twin Disc Clutch Co.**, Racine, Wis. K

Circle 719 on Page 19

Transparent Tape

has high
dimensional stability

Transparent, film-backed tape, designated Paklon No. 681, resists water, acids, alkalies, and other strong solvents, as well as wide temperature ranges. Tape has high industrial versatility, and has a variety of packaging applications. It is exceptionally clear and readily usable with most manual, semiautomatic, and fully automatic dispensers and applicators. It possesses a long-aging

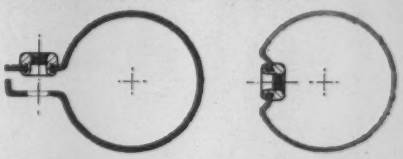


ATTACHMENT AND FASTENING

PROBLEM SOLVER

. . . applied with standard TRS riveting machines

EXAMPLE: in a pipe clamp and a sleeve attachment

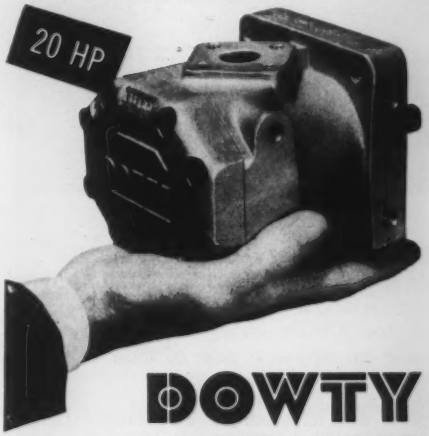


Set in flange of pipe clamp before forming into a circle, Perma-Nut makes a neat, permanent, strong nut plate. Set in dimple to recess clinch, second Perma-Nut makes threaded fitting for attachment screw in two-section tubular handle.

Solve your attachment design problems with PERMA-NUTS. Get the production speed and economy that go with automatic feeding and setting of standard semi-tubular rivets — plus all the fastening flexibility of threaded fittings. A nut plus a rivet, with a built-in "lock washer"! *Write for your free copy of this fact-filled problem-solving catalog.*

TUBULAR RIVET & STUD CO.
Quincy 70, Mass.

Circle 540 on Page 19



A HANDFUL OF POWER

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HYDRAULIC GEAR PUMPS

Pressures to 2500 PSI • Outputs from 1/2-60 GPM

Shown here is our Model GP2-85 which will deliver 18 GPM at pressures to 2000 PSI. Volumetric efficiency exceeds 95% throughout the operating range. Fully pressurized lubrication independent of discharge pressure. 14 other sizes available.

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A Division of Oliver Tyrone Corp.

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Pittsburgh 22, Pa.

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Company_____
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Circle 541 on Page 19

REEVES *Vari-Speed Motodrives*

mean versatility in variable speed

REEVES
101 different standard assemblies
18 different standard right angle assemblies
9 different standard inverted vertical assemblies
32 different standard flange assemblies

There's a *standard* REEVES Motodrive for virtually *any* installation. Rugged, compact variable speed . . . ¼ to 20 hp. . . . 1.7 to 4660 rpm. . . . 2:1 thru 10:1 speed variation. Other units up to 40 hp. There's space-saving versatility, too. Choose either "C" flow style (illustrated) or "Z" flow (motor on opposite side of case from output shaft).

Extra precision . . . a complete line of controls, ie. AIRtrol (a pneumatic positioner), electric remote control, mechanical controls, magnetic brakes and tachometers. **Extra versatility** . . . to meet specific needs, REEVES offers a full array of modifications, ie. special motors, shaft extensions and scoop mountings for foot-mounted motors.

IT'S ALL HERE! 96 pages of ratings, dimensions and prices. Write for your copy now . . . on company letterhead only, please.

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R MASTER REEVES

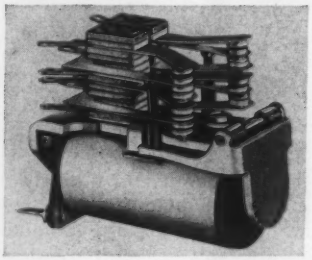
adhesive designed for instant contact. Because of high dimensional stability, the vinyl tape remains unchanged by even severe atmospheric conditions and is not affected by either humidity or moisture. Tape, 2.8 mil thick, has tensile strength of 30 lb per in. width and can be dispensed easily without special cutting blades. It is available in both boxed and bulk form in widths from ¼ to 43 in. and lengths of 72 yd. **Minnesota Mining & Mfg. Co.**, 900 Bush Ave., St. Paul 6, Minn. J

Circle 720 on Page 19

Telephone-Type Relay

for ac operation

Reliable operation and long service life are featured in medium-sized telephone-type relay engineered for 60 cycles, ac, and designated Class 66A. Shaded-pole construction assures maximum contact pressures.



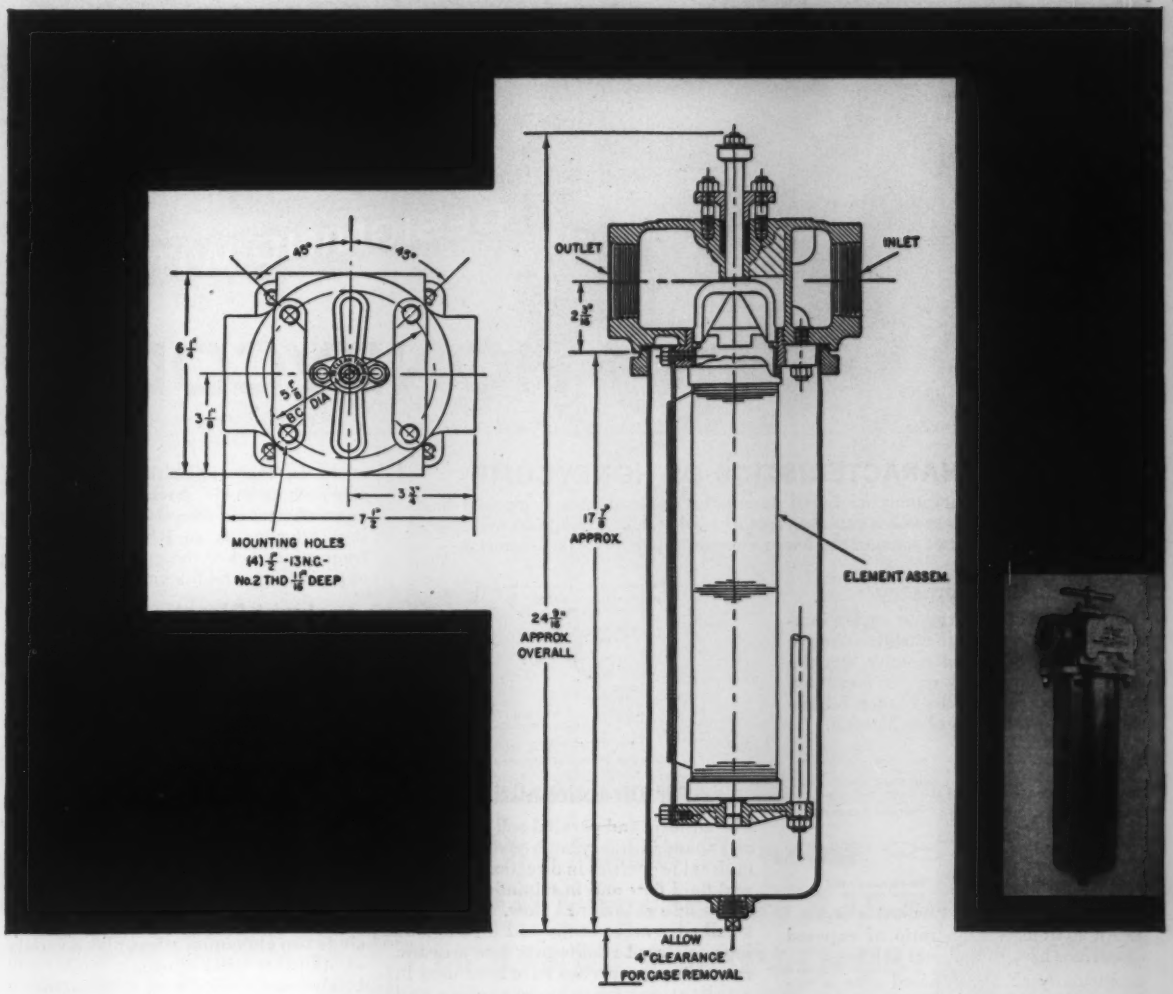
Relay is available with contact combinations up to four pole, double throw, with wide selection of contacts for all types of applications. Unit is furnished for operating voltages to 250, 60 cycles, ac, in open style, with dust cover, or with hermetically sealed enclosures. **Magnecraft Electric Co.**, 3350 W. Grand Ave., Chicago 51, Ill. I

Circle 721 on Page 19

Hydraulic Boost Pump

provides fluid to high-pressure piston pumps

High-speed, high-performance hydraulic boost pump delivers a minimum of 31 gpm at 3450 rpm, using MIL 5606 or 6083 fluids at 160 F. It provides an instant, sufficient supply of fluid to high-pressure piston pumps on missile and aircraft test stands, overcoming dry starts and pump starvation. Unit operates



This one standard Purolator filter is

EXACTLY RIGHT *for all these fluids:*

inks • paints • varnishes • food products • greases • process fluids • fuel and lube oils

SPECIFICATIONS: This Purolator filter model G-141J—is designed for filtration in a range upward of 40 microns.

It can be installed on pressure or suction side of pump.

It is recommended for capacities of from 6 to 200 GPM, dependent on viscosity. Spacing varies from .0010 to .020.

Relief valves set from 10-12 (generally 15 to 20) to 50 PSI are incorporated in several models.

Motor driven knife blade to clean element can be furnished whenever conditions make manual rotation impractical.

Maximum pressure: 125 PSI; weight: 37 lbs. Equipped with simplex full-flow metal element oil strainers.

Available in all stainless steel construction for corrosive liquids, process fluids, food products.

If this filter's specifications recommend it for a problem of yours, write for application information.

Filtration For Every Known Fluid

PUROLATOR

PRODUCTS, INC.

RAHWAY, NEW JERSEY AND TORONTO, ONTARIO, CANADA

Circle 543 on Page 19

#4 CHARACTERISTICS OF HONEYCOMB

While honeycomb has found its greatest application in composite sandwich structures it is expected that a broad area of application will appear as a result of some of the lesser known properties of this material.

Basic Geometry

Hexcel honeycomb is made by laminating strips of foil together with adhesive lines located in such a manner that the resulting bonded stack can be expanded to form hexagonal cells. Figure 1 illustrates various degrees of expansion.

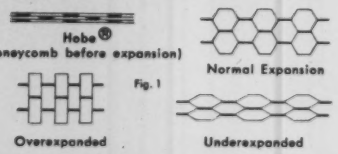


Fig. 1

This basic geometry provides:

1. An extremely high ratio of exposed surface area to the total volume.
2. Virtually all the exposed area is enclosed in regularly oriented unidirectional cells.
3. By varying the cell size and the degree of expansion virtually unlimited adjustment of the foil area to volume relationship may be obtained, as shown in Figure 2.
4. Fluids or gases transmitted through this honeycomb material all travel in the same direction and are uniformly exposed to the surface area.

Physical sizes available include hexagonal cell sizes from ⅛ inch to 1½ inch, cell depths from .060 to 24 inch, and piece sizes up to 42 inch by 96 inch.

5478

INFORMATION REQUEST

Send to Hexcel Products Inc. Dept. 54
2332 Fourth Street Berkeley 10, California.

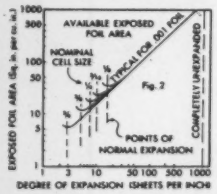
NAME_____

TITLE_____

COMPANY_____

STREET_____

CITY_____ ZONE___ STATE_____


AVAILABLE EXPOSED FOIL AREA
NOMINAL CELL SIZE
TYPICAL FOR .001 FOIL
COMPLETELY UNEXPANDED
POINTS OF NORMAL EXPANSION
EXPOSED FOIL AREA (Sq. in. per cu. in.)
DEGREE OF EXPANSION (SHEETS PER INCH)
Fig. 2

Air Directionalizing

The uniform and parallel cell orientation of expanded honeycomb gives it rather unusual properties in directionalizing air and fluid flow and in minimizing turbulence and rotational flow. Extremely small edge areas of the .001 inch to .004 inch foil used results in a low pressure loss. These properties have been used in applications from home coolers and grilles to wind tunnel straightening vanes. A piece of honeycomb oriented at an angle to the direction of flow can be used as a directionalizing material. Figure 3 illustrates the efficiency of honeycomb as used in grilles and registers.

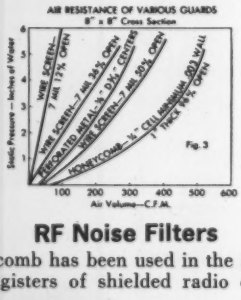


Fig. 3

RF Noise Filters

Honeycomb has been used in the grilles and registers of shielded radio equipment. In this application, honeycomb acts both as an RF shielding device and as an efficient air directionalizing device. It is effective as an RF shield for all frequencies below the cut-off frequency of the cell size and thickness used.

Light Directionalizing

One grade of aluminum honeycomb, HONEYLITE®, has found wide application as a lighting louver, particularly in overall luminous ceiling applications. This characteristic of honeycomb indicates broader use in the collimation of not only visible light, but also ultraviolet and infrared.

Heat Exchangers

The extreme high ratio of surface area to unit volume provided by honeycomb materials can offer many possibilities in heat exchanger applications. Materials available for use in this application include two aluminum alloys plus a variety of stainless steel alloys, in both resin bonded and welded node construction.

Anti-Slosh Devices

Honeycomb has been used as a baffle or anti-slosh device both in fully enclosed sandwich fuel cell structures and in non-sandwich applications. The material can be readily drilled for lateral flow from cell to cell.

Design Opportunities

It can be seen that honeycomb offers to the designer many properties and possible combinations of properties which open up wide areas of potential application. The applications themselves seem limited only by the imagination of those who make use of the material.

Others in This Series. Copies sent on request

1. **Honeycomb Sandwich Panels**
2. **Honeycomb Sandwich Materials**
3. **Successful Honeycomb Sandwich Design**

HEXCEL® PRODUCTS INC.
World leader in honeycomb
Executive Offices: 2332 Fourth Street, Berkeley 10, Calif.
Plants: Oakland and Berkeley, Calif.; Havre de Grace, Md.
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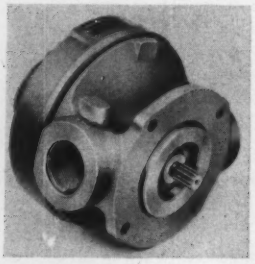
Circle 544 on Page 19



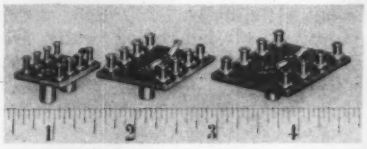
with inlet conditions ranging from 125 psi to over 18 in. Hg. With optimum operating speed matched to speed of prime mover, pump is mounted in direct drive, eliminating gear trains, clutches, and belts. Standard model, No. 702, is supplied with AND 20,001 mounting pad and shaft-end configuration. **Double A Products Co.**, Manchester, Mich. H

Circle 722 on Page 19

Terminal Boards

for resistor mounting

Cambion eight-lug terminal boards, of 1/16-in. thick glass fiber impregnated with melamine resin, are available in three sizes for resistor mounting. Board No. 1450 is $\frac{7}{8}$ x 23/32 in. with terminal rows $\frac{1}{2}$ in. apart; No. 1451 is 1 7/32 x 1 1/32 in. with terminal rows $\frac{3}{4}$ in. apart; No. 1452 is $1\frac{1}{2}$ x 1 5/32 in. with terminal rows $\frac{7}{8}$ in. apart. Terminals extend 3/16 in. above boards. Each board has rounded strap swaged to mounting studs for positive rf grounding. Boards are available in any quantity. **Cambridge Thermionic Corp.**, 445 Concord Ave., Cambridge 38, Mass. B



Circle 723 on Page 19

Quick-Action Clamp

is completely self-contained

Quick - action clamp known as TA5000 can be opened and closed easily and indefinitely without distortion. Completely self-contained, it has no loose parts and is suitable for all types of electrical, hy-

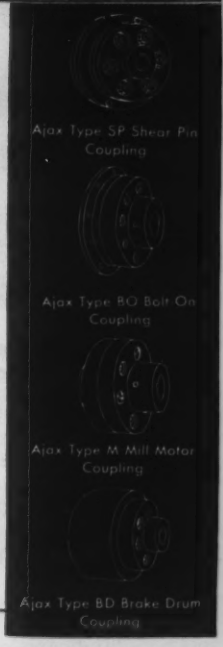
ALL THE HORSEPOWER GOES THROUGH THE COUPLING

The Basic Reason Why it Pays to Use AJAX FLEXIBLE COUPLINGS!

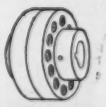
For Original Equipment and Replacement... It costs far less to safeguard bearings, gears, impellers, armatures, housings, and other working parts than today's high cost of repairs and shutdowns!

Whether you design, build, install, operate or service direct-connected machines, look into all extra economies of AJAX FLEXIBLE COUPLINGS.

Made in a complete line of types and sizes,—phone or write for catalog.


Ajax Type SP Shear Pin Coupling
Ajax Type BO Bolt-On Coupling
Ajax Type M Mill Motor Coupling
Ajax Type BD Brake Drum Coupling

RUBBER-CUSHIONED SLEEVE BEARING TYPE



DIHEDRAL GEAR TYPE

AJAX

AJAX FLEXIBLE COUPLING CO. INC.
102 Portage Road, Westfield, N. Y.
In Canada—The Alexander Fleck, Ltd., Ottawa

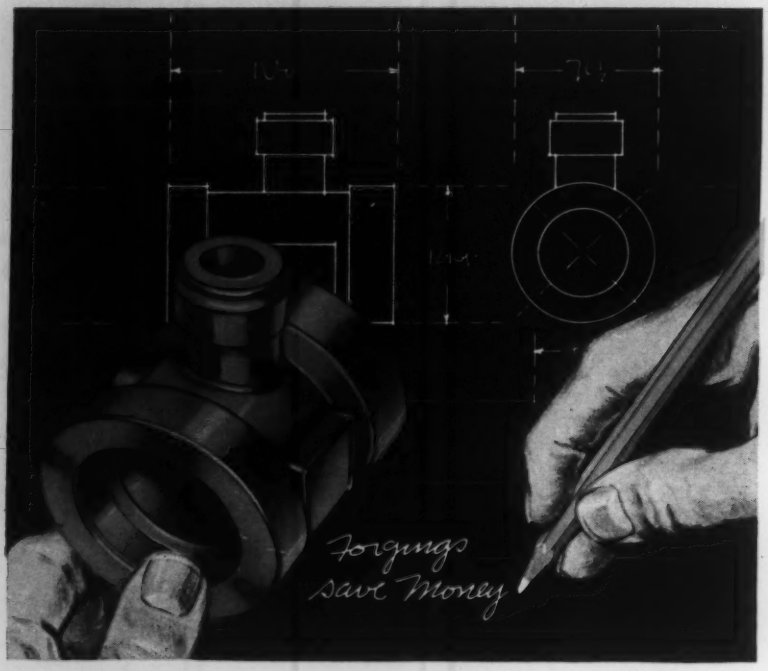
Send catalog covering Flexible Couplings.

Name_____
Concern_____
Address_____

Circle 545 on Page 19

DESIGN YOUR PART AS A BRIDGEPORT CORED FORGING

SAVE MATERIAL . . . SAVE LABOR



You can design efficiency and savings into your product with Bridgeport Cored Forgings.

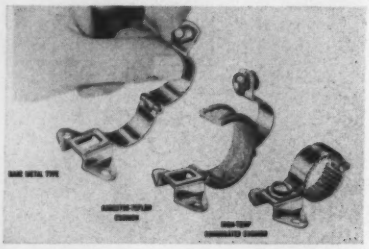
For example, by switching from a solid forging to a cored forging in the production of a fire-extinguisher discharge head, a 20% saving in labor and a 45% saving in metal were realized by one manufacturer. The cored forged part weighed only 2¼ lbs. versus 4⅛ lbs. for the solid brass forging. This weight advantage, along with lower machining costs when new combination tools were used, was achieved with just one stroke of the forging press!

Bridgeport Cored Forgings give your metals components qualities unequaled by any other metal-forming method. They can reduce machining and finishing, lower metal requirements and tool costs.

Stronger parts and components without flaws can be designed to eliminate assembly operations. All these design advantages bring new efficiency to your part and production methods.

A book on the subject, "Bridgeport Forgings," is yours for the asking. Write Dept. 8906.

CORED FORGING DIVISION
BRIDGEPORT BRASS COMPANY
1000 Connecticut Ave., So. Norwalk, Conn.
Specialists in Metals from Aluminum to Zirconium



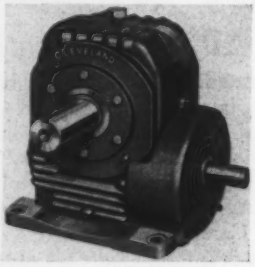
draulic, and pneumatic lines that have to be removed periodically. Rugged hinge built into parent metal itself allows clamp to be opened and closed without binding or distorting. Quick-disconnect nut can be disengaged with screwdriver on integrated bolt head. Unit can be opened and closed without removing clamp from fixed mount. Fastener is available in sizes from ¼ to 6-in. diam in stainless steel. Asbestos-Teflon, neoprene rubber, AW aromatic fuel and weather-resistant cushion, and corrugated stainless cushioning materials are available. **TA Mfg. Corp.**, 4607 Alger St., Los Angeles 39, Calif. L

Circle 724 on Page 19

Speed Reducers

from 1 to 40-hp size are fan cooled

High-horsepower speed reducers transmit as much as 80 per cent more horsepower than conventional wormgear units. Reducers range from 1 to 40 hp at present time. Housings of fan-cooled units are one-piece designs of high-quality



cast iron, ribbed for maximum strength and heat dissipation. Cooling fan is mounted on input end of worm shaft and is equally efficient in either direction of rotation. Housing is designed for mounting in one position only. Worms are cut integral with shaft and accurately ground to high surface finish on both thread flanks. Gears have cen-

BRIDGEPORT BRASS STRIP...

Peterson Manufacturing Company, Kansas City, produces the auto accessories shown here.

STOPS Rising Production Costs of Vital Automotive Accessories

Spotlights, stop lights, reflectors and a host of vital auto accessories are most economically produced from Bridgeport Cartridge Brass Strip (Alloy 69). The ease with which Alloy 69 can be formed is the key to the cost savings. In fact, Cartridge Brass has replaced stainless steel in many of these applications.

Superior deep-drawing properties in Cartridge Brass make it possible to reduce the number of forming operations to a minimum. Rejects are also eliminated, for Alloy 69 has the ductility and strength to take progressive forming operations without rupture or cracking. And the finish remains fine during processing – fine for the chrome plating needed to give auto lamps reflective brilliance. The added plus of high scrap value for brass gives manufacturers a final dollars-and-cents reason to lower manufacturing costs by forming parts from a forming material—Cartridge Brass Strip.

Lamps are not the only products that save from the formability of Cartridge Brass Strip. Grillwork and grommets, snap fasteners and spun products, eyelet machine items and every progressively formed product can enjoy minimum unit costs with this one-of-a-hundred Bridgeport Metals. For a complete list, and mechanical-physical properties comparison, write today for a copy of the folder, "Bridgeport Alloys, Copper, Brass, Bronze." Please address Dept. 4307.

BRIDGEPORT BRASS COMPANY

Bridgeport 2, Conn. • Sales Offices in Principal Cities

Specialists in Metals from Aluminum to Zirconium

Circle 547 on Page 19

lasting beauty for heaters with aluminum Minimesh grilles

Abundant use of Minimesh enhances the appearance of this gas heater by Quad, Inc., Columbus, Ohio

Quad gas heaters are designed to look attractive and to deliver the heat with top efficiency, year after year. To help meet these objectives, the grilles are made from Penmetal aluminum Minimesh.

The diamond pattern contributes undeniable smartness. Made of anodized aluminum, the grilles will always look new.

Minimesh has the strength to stand up under every-day use; the rigidity to span large areas in an unbroken sweep. Furthermore, the open mesh permits heat to circulate freely.

A grille made from Minimesh is an unmistakable sign of quality. A quality that gives distinction to any product. A quality that changes eyers to buyers.

Folder 510-EM will help you in the selection of Minimesh. Send for a copy today.

PENN METAL COMPANY, INC.

General Sales Office: 40 Central Street, Boston 9, Mass.

Plant: Parkersburg, W. Va.

District Sales Offices: Boston, New York, Philadelphia, Pittsburgh, Chicago, Detroit, Dallas, Little Rock, Seattle, San Francisco, Los Angeles, Parkersburg, St. Louis

Penmetal

a name to remember

PM-205

Another Quad heater featuring Minimesh grille.

Circle 548 on Page 19

Simplified built-in pump elements save space, weight, costs

It's no longer necessary to buy complete pumps for handling fluids at pressures up to 1,000 psi. Now . . . for a fraction of the cost . . . you can design three simple components integrally into your mechanisms and get equal or better performance.

Fig. 1. Three Gerotor components permit pump to be incorporated as integral part of housing or frame of mechanism, eliminate need for purchase and mounting of separate, complete pump.

Three matched components are all you need buy. *(Fig. 1.)* Consisting of an inner and outer Gerotor and an eccentric locator-ring, the unit becomes a complete pump by simply boring the casting or frame of the mechanism to accommodate the eccentric ring O.D. and by providing porting. This design makes the main casting do double duty as the pump housing, thus eliminating a very considerable cost factor. A drive can be taken from any convenient shaft.

Gerotor Insert-Packages can be designed and mass-produced to deliver up to 100 gpm and 1,000 psi within a wide range of mechanism geometry. That's because Gerotor pump capacity is a function of diameter, thickness, number of teeth and rpm of the two moving parts. These variables can be matched to just about any space restriction and capacity requirement.

Your built-in pump will give you all the advantages that make Nichols positive-displacement Gerotor pumps first choice for numerous applications: It, is lightweight, valveless, self-priming, long-wearing, balanced and extremely quiet. In addition, it has high mechanical and volumetric efficiency. *(Fig. 2.)*

FIG. 2

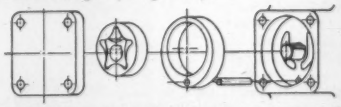


Fig. 3. Nichols integral pump-package is as easily installed as an anti-friction bearing.

Investigate this concept of integral pump design. Our technical assistance is on call at all times to show you how to build these low-cost packages into your equipment. *(Fig. 3.)* Write:

W. H. NICHOLS CO.
Woerd Ave., Waltham 54, Mass.

Circle 549 on Page 19

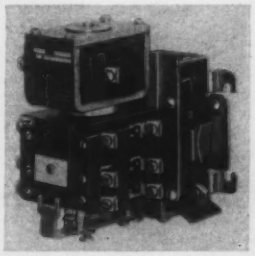
trifugally cast bronze rims with high tin-nickel content, made integral with cast-iron center. Bronze rims provide high density and hardness, giving resistance to wear and fatigue pitting. Bearings provide adequate thrust and radial capacity, and worm bearings are mounted directly in housing bore for rigidity. **Cleveland Worm & Gear Co.**, 3300 E. 80th St., Cleveland 4, Ohio. F

Circle 725 on Page 19

DC Relay

is mechanically held type

New dc relay has been added to a line of Type D relays for ac and dc pilot control. Mechanically held attachment mounts in a manner identical to ac attachment, and no



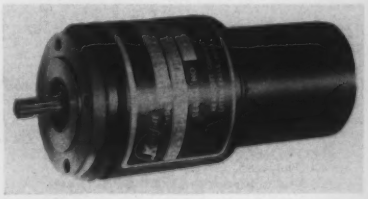
additional panel space is required. Standard Type D electrically held dc relay easily mounts directly on attachment, and dc coils are available in a variety of voltages. **Square D Co.**, 4041 N. Richards St., Milwaukee 12, Wis. K

Circle 726 on Page 19

Servo Motor

Size 15 unit is for high-temperature use

High-performance T1311-22 servo motor, a size 15 unit, operates effectively at temperatures from −54 to +200 C. Unit consists of a stand-



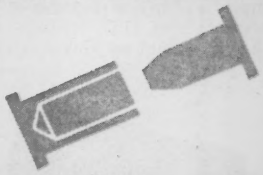
ard servo motor to which a drag cup integral with rear shaft extension has been added. By this means, effective damping in systems having

(Please turn to Page 242)

AUTOMATIC ASSEMBLY

IS FAST,

ECONOMICAL,



TROUBLE-FREE

with Milford tubular rivets and automatic riveters

Mass production and automatic assembly cut costs only when all operations are trouble-free. That's why the high strength and uniform quality of Milford Tubular Rivets, plus Milford's wide line of precision riveters, are playing an active role in slashing today's production costs.

For the answers to assembly problems . . . *get in touch with Milford first!*

THE MILFORD RIVET & MACHINE CO.

MILFORD, CONNECTICUT • HATBORO, PENNA.
ELYRIA, OHIO • AURORA, ILL. • NORWALK, CALIF.

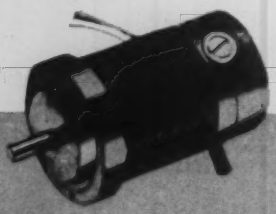
Circle 550 on Page 19

BIGGER CHOICE ...LOWER COST!

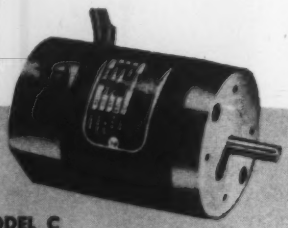
HOWARD

Howard alone offers such an all-inclusive line of Universal and D.C. motors—including over 65,000 specs on file for every conceivable application. With this vast source to draw from chances are there are specs on hand to meet your requirements. That's why Howard can provide the motor you need, more quickly and at lower cost. Shown here are just a few of the standard models in the Howard line. For complete information, samples and prices on these or other Howard Universal and D.C. motors—from 1/200th to 1 H.P.—send us your specifications today.

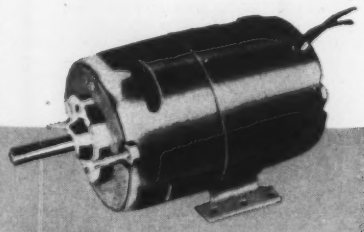
1/200th TO 1 H.P.— High Speed, High Starting Torque



MODEL B
TYPE: Universal AC/DC or DC Shunt
DIAMETER: 1-11/16
LENGTH: 2-3/16 to 3-11/16
H.P.: Continuous 1/40
Intermittent 1/20
Full Load Speed—Series 5200 to 10,000 R.P.M.
Shunt — 1800 to 10,000 R.P.M.
VOLTAGES: Series — 6 to 115V, AC-DC
Shunt — 6 to 120V DC
BEARINGS: Precision grease sealed ball bearings.

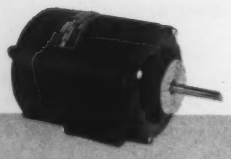


MODEL C
TYPE: Universal AC/DC or DC Shunt
DIAMETER: 2-1/4
LENGTH: 2-9/16 to 3-9/16
H.P.: Continuous 1/25
Intermittent 1/12
Full Load Speed—Series 5200 to 10,000 R.P.M.
Shunt — 1800 to 10,000 R.P.M.
VOLTAGES: Series — 6 to 115V, AC-DC
Shunt — 6 to 120V DC
BEARINGS: Precision grease sealed ball bearings.



MODEL F
TYPE: Universal AC/DC or DC Shunt
DIAMETER: 3-1/2
LENGTH: 4-1/8 to 5-11/32
H.P.: Continuous 1/2
Intermittent 3/4
Full Load Speed—Series 3800 to 10,000 R.P.M.
Shunt — 1800 to 10,000 R.P.M.
VOLTAGES: Series — 6 to 115V, AC-DC
Shunt — 6 to 120V DC
BEARINGS: Precision grease sealed ball bearings.

MODEL 243
TYPE: Universal AC/DC or DC Shunt.
DIAMETER: 2-17/32.
LENGTH: 3-15/16.
H.P.: Continuous Series—1/12 @ 10,000 R.P.M.
Intermittent—1/8 @ 10,000 R.P.M.
SPEED: Full Load Speed:
Series—5000 to 10,000 R.P.M.
Shunt—2000 to 7000 R.P.M.
VOLTAGES: Series—12 to 230V. AC/DC.
Shunt 6 to 120V. DC.
BEARINGS: Porous bronze self aligning type with oil reservoir.



MODEL 29-500
TYPE: Universal AC/DC or Shunt.
DIAMETER: 3-5/16.
LENGTH: 4-11/16 to 5-19/32.
H.P.: Continuous: Series—1/6 @ 10,000 R.P.M.
Shunt or Compound—1/12
Intermittent Series—1/4 @ 10,000 R.P.M.
Shunt or Compound—1/6.
SPEED: No Load: Series—15,000 R.P.M.
Shunt or Compound—12,000 R.P.M.
Full Load Speed: Series—3000 to 10,000 R.P.M.
Shunt or Compound—1000 to 10,000 R.P.M.
VOLTAGES: Series—6 to 250V. AC/DC.
Shunt or Compound—6 to 230V. DC.
BEARINGS: Porous bronze sleeve type or grease sealed ball bearings.

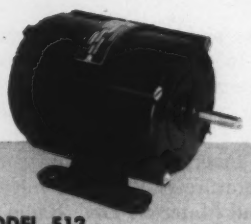
MODEL 11A
TYPE: Universal AC/DC or DC Shunt.
DIAMETER: 2.825".
LENGTH: 3-9/16".
H.P.: Continuous 1/75.
Intermittent: 1/20.
SPEED: No Load Speed: Series — 15,000 R.P.M.
Shunt — 3500 to 12,000 R.P.M.
Full Load Speed: Series — 3000 to 10,000 R.P.M.
Shunt — 2000 to 10,000 R.P.M.
VOLTAGES: Series—6 to 115V. AC-DC.
Shunt — 6 to 120V. D.C.
BEARINGS: Porous bronze self aligning type with felt oil reservoir.

COMPLETE LINE OF UNIVERSAL & DC FRACTIONAL H.P. MOTORS

MODEL 11-12
TYPE: Universal AC/DC or DC Shunt.
DIAMETER: 2-25/32". 2-9/32" flat side.
LENGTH: 4-19/32".
H.P.: Continuous Series—1/15 @ 10,000 R.P.M.
Shunt—1/20.
Intermittent: Series—1/6 @ 10,000 R.P.M.
Shunt—1/8.
SPEED: No Load Speed: Series—18,000 R.P.M.
Shunt—3500 to 10,000 R.P.M.
Full Load: Series—5000 to 10,000 R.P.M.
Shunt—2000 to 10,000 R.P.M.
VOLTAGES: Series—6 to 230V. AC/DC.
Shunt—6 to 120V. DC.
BEARINGS: Porous bronze self aligning type with felt oil reservoir, or grease sealed ball.

MODEL 106
TYPE: Series or Shunt DC only.
Diameter: 2-5/16".
LENGTH: 3.89". 3.85".
H.P.: Continuous: Series—1/35 @ 10,000 R.P.M.
Intermittent: Series—1/10 @ 10,000 R.P.M.
Shunt—1/10.
SPEED: Full Load Speed: Series—5000 to 10,000 R.P.M.
Shunt—1800 to 10,000 R.P.M.
VOLTAGES: Series—6 to 120V. DC.
BEARINGS: Grease sealed ball bearings.

MODEL 200
TYPE: Universal AC/DC or DC Shunt.
DIAMETER: 1-11/16".
LENGTH: 2-11/16".
H.P.: Continuous Series—1/200 @ 10,000 R.P.M.
Shunt—1/200.
Intermittent: Series—1/75 @ 10,000 R.P.M.
Shunt—1/75.
SPEED: No Load Speed: Series—15,000 R.P.M.
Shunt—15,000 R.P.M.
Full Load Speed: Series—3000 to 10,000 R.P.M.
Shunt—3000 to 10,000 R.P.M.
VOLTAGES: Series—6-115V. AC/DC.
Shunt—6 to 32V. DC.
BEARINGS: Grease sealed ball bearings.



MODEL 512
TYPE: Universal AC/DC or DC Shunt
DIAMETER: 3-3/8". LENGTH: 4-3/4".
H.P.: Continuous Series—1/10 @ 10,000 R.P.M.
Shunt—1/12.
Intermittent: Series—1/5 @ 10,000 R.P.M.
Shunt—1/6.
SPEED: No Load Speed: Series—15,000 R.P.M.
Shunt—2000 to 12,000 R.P.M.
Full Load Speed: 5000 to 10,000 R.P.M.
Shunt: 1000 to 10,000 R.P.M.
VOLTAGES: Series—6 to 230V. AC/DC.
Shunt—6 to 120V. DC.
BEARINGS: Porous bronze sleeve type.

MODEL 700
TYPE: Universal AC/DC or DC Shunt.
DIAMETER: 3.800".
LENGTH: 5-7/64". to 6-7/64".
H.P.: Continuous: Series—1/4 @ 10,000 R.P.M.
Shunt—1/8.
Intermittent: Series—1/2 @ 10,000 R.P.M.
Shunt—1/4.
SPEED: No Load Speed: Series—18,000 R.P.M.
Shunt—2000 to 12,000 R.P.M.
Full Load Speed: Series—5000 to 10,000
Shunt—1000 to 10,000 R.P.M.
VOLTAGES: Series—6 to 115V. AC/DC.
Shunt—6 to 230V. DC.
BEARINGS: Grease sealed ball bearings.

MODEL 1100
TYPE: Universal AC/DC or DC Shunt.
DIAMETER: 2-13/16". LENGTH: 3-9/16".
H.P.: Continuous: Series—1/30 @ 10,000 R.P.M.
Shunt—1/30.
Intermittent: Series—1/15 @ 10,000 R.P.M.
Shunt—1/15.
SPEED: No Load: Series—15,000 R.P.M. approx.
Shunt—3500 to 12,000 R.P.M.
Full Load: Series—3000 to 10,000 R.P.M.
Shunt—2000 to 10,000 R.P.M.
VOLTAGES: Series—6 to 230V. AC/DC.
Shunt—6 to 120V. DC.
BEARINGS: Porous bronze sleeve type, or Grease Sealed Ball Bearings.

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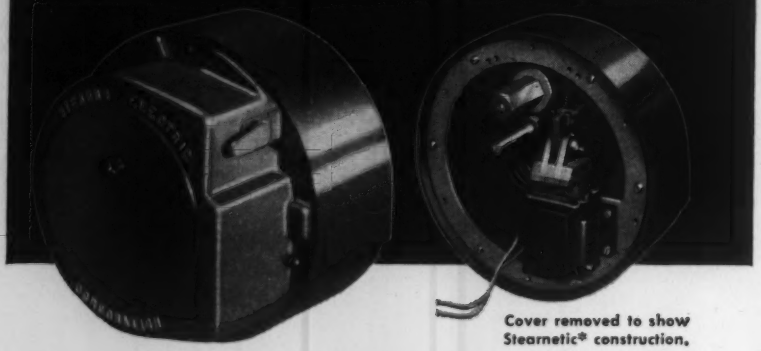


Cover removed to show Stearnetic* construction.

*Stearnetic — Stearns exclusive unitized, electro-magnetic operating mechanism.

...up to 33% shorter
permits more compact, space-saving installations — less overhang . . . as much as 3 in. shorter than competitive units — up to 4½ in. shorter than previous high-torque Stearns brakes.

...up to 50% lighter
easier to handle and install — cost less to ship . . . up to 50% lighter than competitive units.

★ Max. Torque Range — 125 to 575 lb ft.
★ AC or DC models—all single phase — only two lead wires for fast, simple installation.
★ Standard motor or floor mountings . . . two styles of enclosures.
★ Exclusive Stearns "Visi-Wear" indicator.
★ Single point release — single solenoid design.
★ For standard or straight-thru shafts.
★ Exclusive Stearns one-point adjustment for wear.
★ A screwdriver is your complete maintenance tool kit.
★ Wide-range torque variation for stops that match the application.
★ Smooth, clean, modern exterior design to match modern motors — no protruding parts to catch clothing — easy to clean.

Send for Special Information Sheet No. 2F

BRAKES CLUTCHES MILWAUKEE
Stearns ELECTRIC CORPORATION
120 NORTH BROADWAY
MILWAUKEE 2, WISCONSIN

(Continued from Page 239)

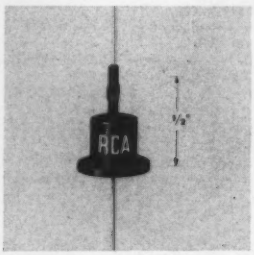
high speed, high gain, or both is achieved. Need for viscous dampers is eliminated without reducing no-load speed and without increase in steady-state errors in position-servo applications. There are no controls to adjust, phasing problems are obviated, and null or pickup problems are removed. **Kearfott Co. Inc.**, 1500 Main Ave., Clifton, N. J. D

Circle 727 on Page 19

Silicon Rectifiers

for industrial and military power supplies

Seven hermetically sealed silicon rectifiers are of diffused-junction type. They are designed for use in power supplies of industrial and military equipment capable of operating at dc forward currents to



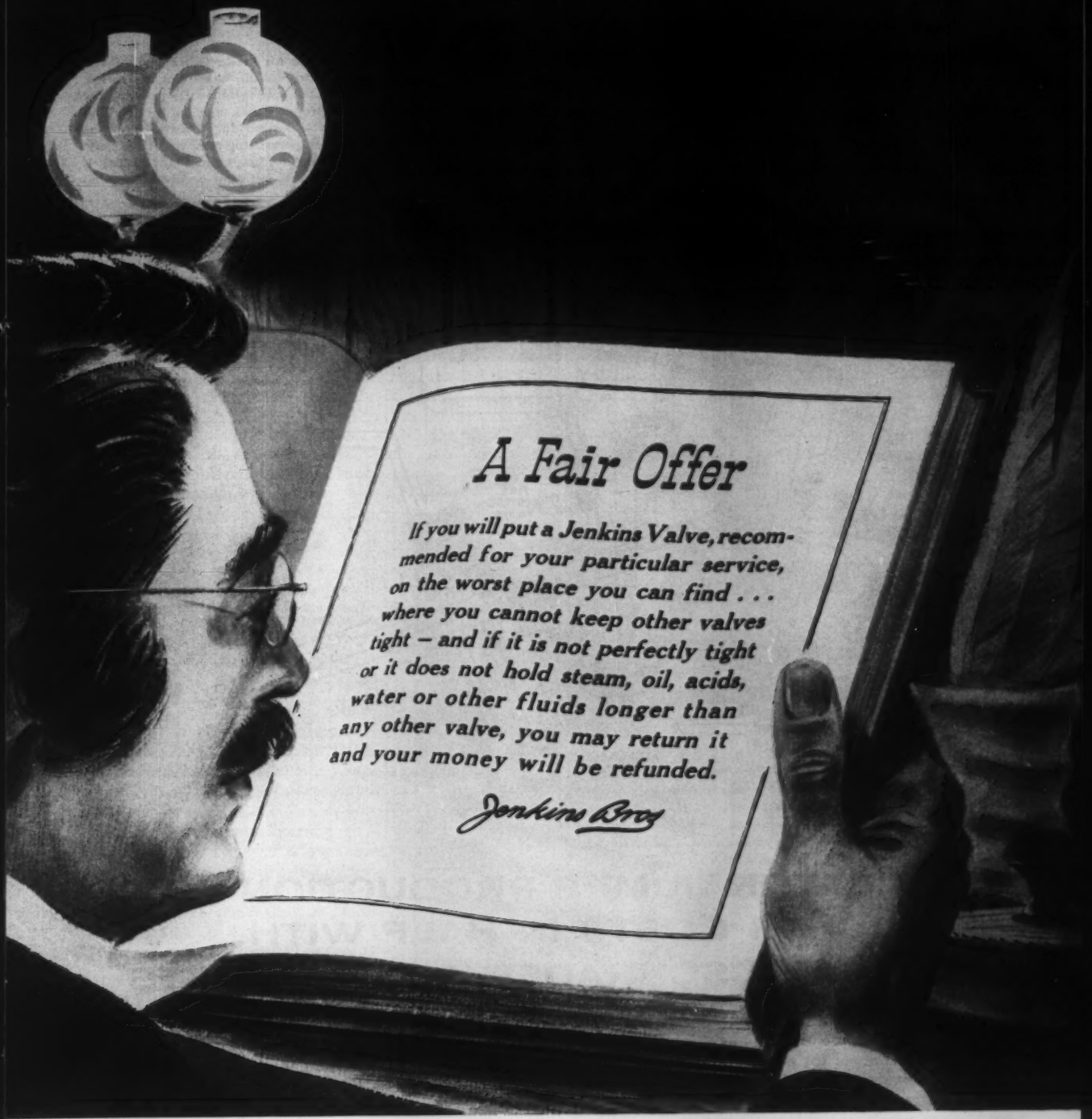
750 ma and temperatures from −65 to +165 C. Rectifiers have peak inverse-voltage ratings from 50 to 600 v, and maximum reverse current of 5 mu amp at maximum rated peak inverse voltage and ambient temperature of 25 C. **Semiconductor and Materials Div., Radio Corp. of America**, Somerville, N. J. D

Circle 728 on Page 19

Felt Insulations

with wide range of densities and surface facings

Spun mineral-wool felt insulations, designed for use in high-temperature industrial equipment, heated appliances, and refrigeration systems, are available in flexible and semirigid densities from 3 to 8 lb per cu ft and with a variety of surface facings. Felts can be used to insulate surfaces having temperatures from below zero to 450 F. If mechanically supported and enclosed, they can be used satisfactorily up to 600 F. Lightweight and


A Fair Offer
If you will put a Jenkins Valve, recommended for your particular service, on the worst place you can find . . . where you cannot keep other valves tight – and if it is not perfectly tight or it does not hold steam, oil, acids, water or other fluids longer than any other valve, you may return it and your money will be refunded.
Jenkins Bros

PUBLISHED AND PROVED FOR 90 YEARS

This simple, straightforward statement of selling policy was first published in 1869, five years after Jenkins Bros. was founded. It has been continued in full effect through 90 years of Jenkins Bros. history of making valves to a standard of quality that warrants such an unparalleled assurance to buyers.

SOLD THROUGH LEADING DISTRIBUTORS EVERYWHERE

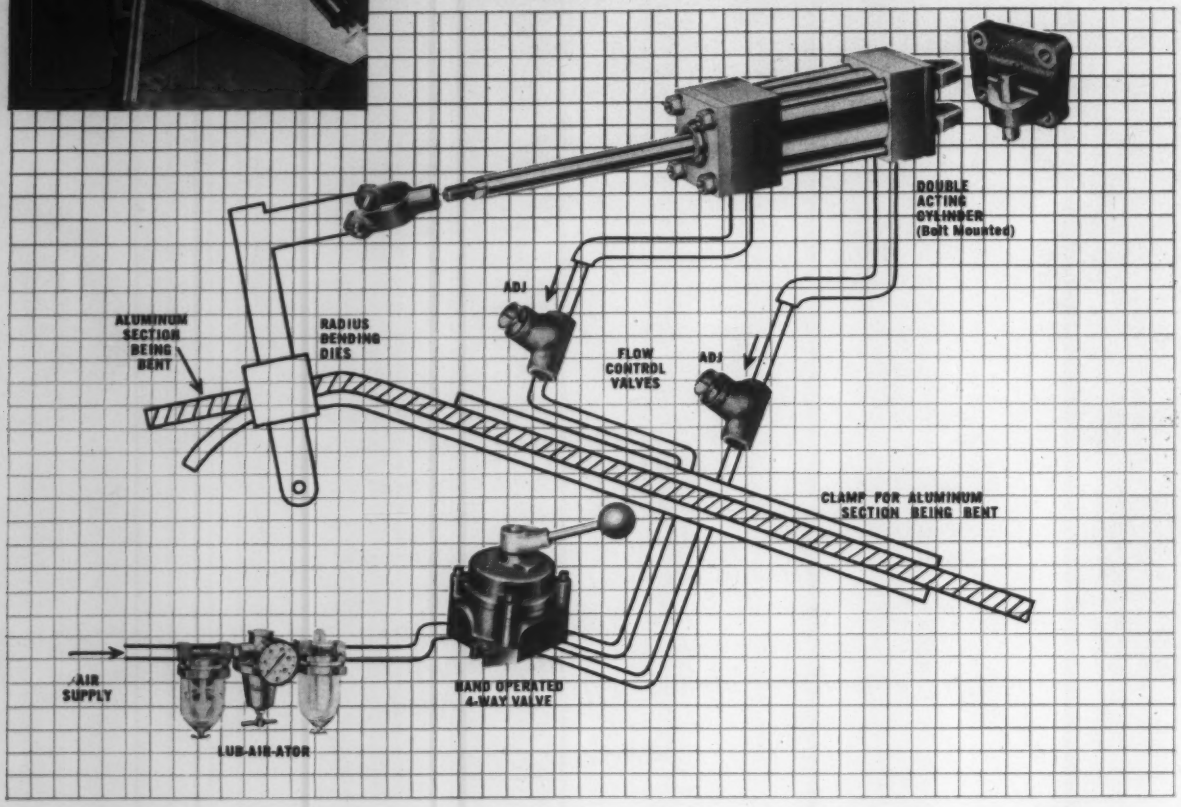
JENKINS VALVES

LOOK FOR THE JENKINS DIAMOND

JENKINS SINCE 1864 Jenkins Bros

Circle 554 on Page 19

A typical example of how fabricators use Schrader. Schrader Air Products in the schematic perform a metal-forming operation at Lance Awning Corporation, Lake Worth, Florida. Power is supplied by a Schrader double-acting bolt-mounted air cylinder. By pressing the Schrader 4-way valve, the cylinder piston advances at proper speed, checked by Schrader flow control valves, bending an aluminum section to the desired angle. Reversal of the 4-way valve returns the cylinder and bending dies to rest, permitting removal of the bend section. "Air control provides a straightforward one-man job," says the Plant Manager. "Two men worked hard to form this radius bend on 25 parts per hour before a Schrader Air Cylinder was installed. Now one man forms 35."



FABRICATOR JUMPS PRODUCTION 40%... CUTS COSTS IN HALF WITH STANDARD SCHRADER AIR PRODUCTS

Get higher production at lower cost, just like this company... with the *air* you already have! You can't beat Schrader Air Products for accuracy, economy, speed —and lasting quality.

Air can save manhours . . . slash operating costs . . . upgrade practically any operation such as inspecting, assembling, testing and packaging. It can push, pull, hold, position and move work repetitively . . . make light of weight-lifting . . . accelerate production . . . unplug bottlenecks . . . all at unmatched low cost and drop-in-the-bucket maintenance.

You get the finest line of Air Cylinders, Valves and Accessories from Schrader. Plan hookups yourself. You get expert help and ideas for cutting your operating costs from experienced Schrader Air Specialists.

Select your automating equipment from the full Schrader line. Your Schrader distributor can help you pinpoint what you need. For more data write:

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Division of Scovill Manufacturing Company, Incorporated
476 Vanderbilt Avenue, Brooklyn 38, N. Y.

QUALITY AIR CONTROL PRODUCTS

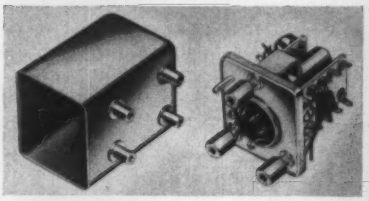
resilient, insulations are incombustible, noncorrosive, and moisture-resistant. They are easy to cut and fit with knife or saw. Felts are available in thicknesses of 1 to 4 in. in ½-in. increments. Sizes are 24, 30, 36, or 48 in. long by 12 or 24 in. wide. **Baldwin-Ehret-Hill Inc.**, 500 Breunig Ave., Trenton 2, N. J. D

Circle 729 on Page 19

Close-Differential Relay

is microminiature unit

Network which utilizes static devices in conjunction with Series 1005 microminiature relay, creates close-differential requirements without use of mechanical devices. Relay has DPDT contact combination



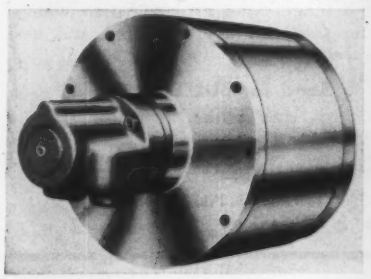
rated at 3 amp. Operating voltage is 24 ±2 v, and release voltage is 22 ±2 v. Maximum differential between attract and release is 2 v, applicable over a temperature range of −65 to +125 C. Relay is hermetically sealed in a housing similar to AN-3304-1, and is available with four-stud-mounting and solder-hook header. **Guardian Electric Mfg. Co.**, 1621 W. Walnut St., Chicago 12, Ill. J

Circle 730 on Page 19

Air Cylinder

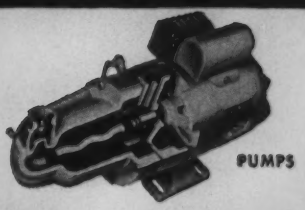
for use at speeds to 3600 rpm

Model RM rotating air cylinder, which actuates chucks, collets, or other rotating holding devices, is for use at speeds to 3600 rpm. Cyl-

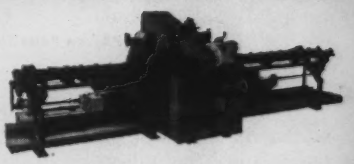


now, about YOUR universal joint design problem . . .

PINSPOTTERS

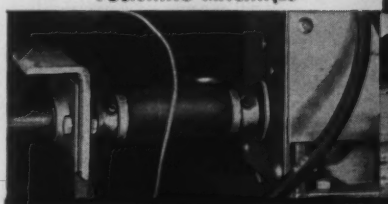


PUMPS



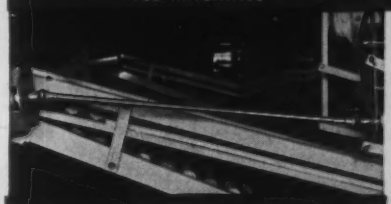
POLISHING MACHINES

MACHINE TOOLS



ICE MACHINES

SUBMARINES



POTATO SORTERS

LEVELERS

Your universal joint design problem may be very similar to one of the many unusual problems for which Apex has already devised a practical solution. Or, it may be entirely different. Either way, you're looking for a universal joint that offers high overload capacity, superior fatigue resistance, lower deflection rate, and a favorable strength-weight ratio per size. Perhaps you're searching for a universal joint that will operate efficiently in wet or dry atmospheres, under corrosive or abrasive conditions, or in extremes of temperatures.

Whatever you require to solve your design problem involving universal joints and assemblies, you'll find it at Apex, where the more difficult problems get special attention. Catalog 28, including our Universal Joint Data Sheets, should prove helpful. Write, on your company letterhead please, for your copy.

• Serving Industry Since 1933 •

THE APEX

Circle 556 on Page 19

Higher-speed operation from built-in gauging

New cam-lever linkage of the Di-Acro Model 36 shear provides a greater mechanical advantage than lever actions. This makes it easier to control both machine and material so that operation is easier, faster and safer.

Quick-Set micrometer gauges set to hair-line accuracy in seconds. The new Model 36 shear is fast to set-up, fast to operate. To maintain tolerances to thousandths of an inch, an automatic hold down bar grips materials during shearing. Notching and slitting can be done easily by setting the adjustable ram stops to limit stroke length. Capacity of the machine is 16 gauge steel.

Steel, rubber, mesh and all shearable sheet materials (even some plastics) can be cut to die-accuracy with the new Model 36.

Similar performance is also delivered by a range of other models down to 6 inches in width. For complete, detailed information, call your Di-Acro distributor who is listed in the yellow pages of your phone book under Machinery—Machine Tools, or write us.

DI-ACRO POWER SHEARS

Di-Acro Shears of 12" and 24" widths are available in power models. The standard model provides continuous and single stroke operation. Vari-O-Speed model shears automatically at a range of speed from 30 to 200 R.P.M. or single stroke.

O'NEIL-IRWIN MFG. CO.
416 8th Ave. Lake City, Minn.
pronounced "die-ack-ro"

di-acro PRECISION METALWORKING MACHINES

Circle 557 on Page 19

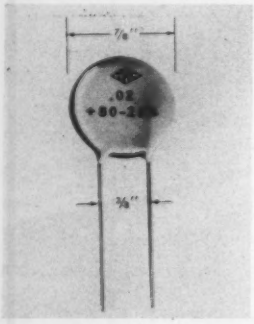
inder has housings and covers of aluminum alloy. Low weight of cylinder and lessened flywheel effect reduce load on machine motor, clutch, and brake, cutting operating and maintenance costs. Double-bearing inlet gives long life at high speeds and fast operating response. Available in 3 to 16-in. bore sizes, cylinders have extra long stroke. Complete assembly, including adapter, is precision balanced to eliminate vibration at high operating speeds. S-P Mfg. Corp., 30201 Aurora Rd., Solon, Ohio. G

Circle 731 on Page 19

Ceramic-Disc Capacitors

withstand extremes of temperature, humidity

DD Series Hi-Kaps are ceramic-disc capacitors with capacitances of 0.03, 0.04, and 0.05 mfd, 600 v dc. Units measure only 7/8 in. in diam and 15/64 in. thick. Durez coated, they are impregnated with high-melting-point wax to withstand extremes of



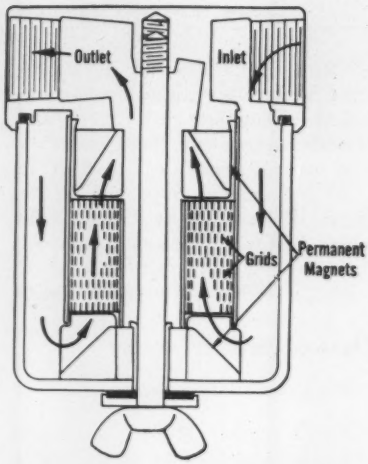
temperature and humidity. No. 22 tinned copper leads are 1½ in. long. Primarily designed for by-pass, coupling, and filter applications, units are available from stock. Centralab, 900 E. Keefe Ave., Milwaukee 1, Wis. K

Circle 732 on Page 19

Interval Timer

for wide range of applications

Known as Series AT-31, compact, totally enclosed, motor-driven interval timer is for use in control of fans, heaters, battery chargers, and photographic equipment. Timer is manually set to a selected interval. At completion of interval, switch opens, de-energizing load and timing motor. Housing is of molded



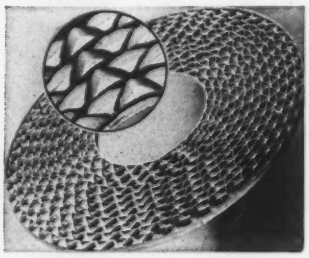
INSIDE STORY of Filter Efficiency

With valves and other components made to extremely close tolerances, hydraulic equipment needs the help of

FERROFILTER®

Magnetic Separators

to keep the circulating fluid free from microscopic ferrous particles.



FERROFILTER GRID

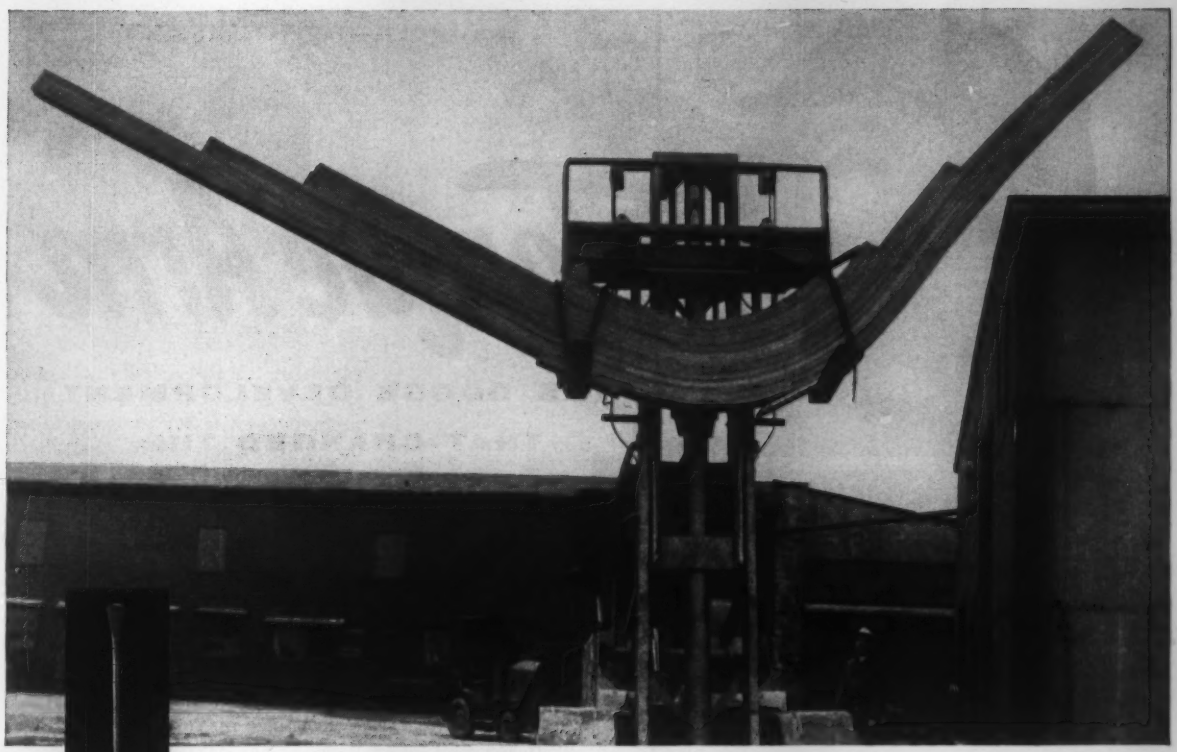
One of a stack of grids, strongly magnetized by two powerful permanent magnets. The grids split the fluid stream into thin elements and force the magnetic particles close to the magnetized grid edges to which the particles are attracted and securely held.

Send for BULLETIN PM-83 and other literature

S. G. FRANTZ CO., Inc.

Brunswick Pike & Kline Ave.
P. O. Box 1138 Trenton 6, N. J.

Circle 558 on Page 19



from paddles... to gunboat stems...

GAMBLE solves problems with WOOD!

The armed forces' solid wood life raft paddles often shattered when dropped from a plane, or splintered when used to "pry" a landing craft onto a beach. Then Gamble Brothers developed a paddle with a shatterproof laminated blade and a dense hardwood handle. Result: a stronger, lighter paddle made with less waste of wood.

The gunboat stem problem was different. Wood, as a non-magnetic material, was specified. But who could engineer and fabricate curved sections of such great cross-sectional depth and width? The answer again: Gamble Brothers, by built-up laminations.

Design problems like these are "all in a day's work" to the wood engineers at Gamble Brothers—a unique organization designing and building a wider variety of wood products than any other U. S. woodworking company. Today they're working in three principal areas: (1) improvement of present wood products (2) development of new wood products (3) product development in combinations of wood and other materials.

Why not present *your* design or component problem to Gamble Brothers? WOOD may be the answer!

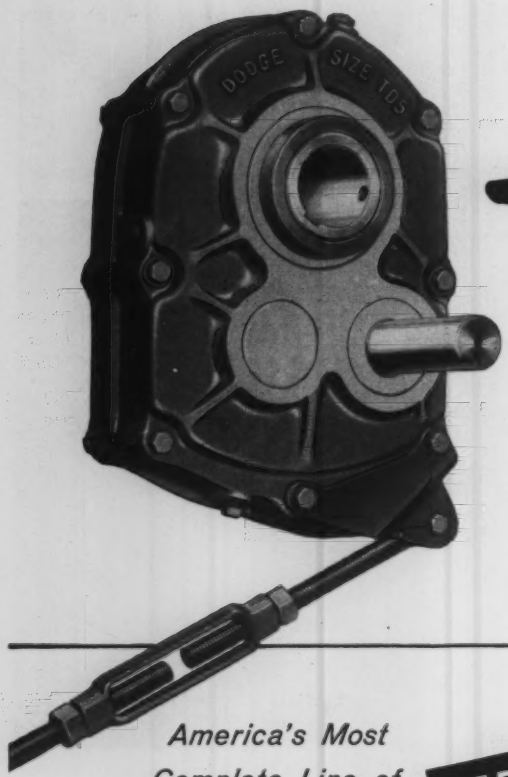
FREE booklet illustrates GAMBLE services

This 28-page booklet describes Gamble facilities and services in detail. Includes many photographs of unusual products designed, tested and perfected by Gamble Brothers. Write for your copy today! Gamble Brothers, Inc., 4619 Allmond Ave., Louisville, Ky.

If the problem involves wood, Gamble can help!

GAMBLE BROTHERS, INC.

4619 Allmond Avenue, Louisville, Kentucky



Torque-Arm

THE DODGE DEVELOPMENT THAT CHANGED THE NATION'S HABITS OF SPEED REDUCTION

America's Most Complete Line of Shaft Mounted Speed Reducers

55 MODELS

- Capacities up to 170 hp
- Output speeds from 10 to 378 rpm!
- Single Reduction
- Double Reduction
- 5 to 1 Ratio
- 15 to 1 Ratio
- 25 to 1 Ratio
- Any speed ratio up to 150 to 1 obtainable by selection of pre-determined combination of reducer and V-belt drive.

CALL THE TRANSMISSIONEER—your local Dodge Distributor. Factory trained by Dodge, he can give you valuable help on new, cost-saving methods. Look in the *white* pages of your telephone directory for "Dodge Transmissioneer."

In fewer than ten years, the range of Torque-Arm Shaft Mounted Speed Reducers has increased from 6 to 55 models, to meet the ever increasing demand for this improved method of speed reduction.

By eliminating foundation, sliding base and flexible coupling this modern speed reducer has saved untold installation time and untold dollars of cost.

The rugged semisteel housing developed by Dodge has never been improved upon. It is corrosion resistant—and it has the strength to hold bearing seats in line for the life of the unit.

Dodge design provides wide spacing for the bearings. Loads are carried easily, contributing to Torque-Arm's long life and very high efficiency. The gears are finest quality—helical, heat treated steel.

Torque-Arm mounts vertically or horizontally in any position around the driven shaft. It locks to the shaft on *both* sides of the housing. The holes in the output hub provide simple removal with puller. Overload release and built-in backstop are optional.

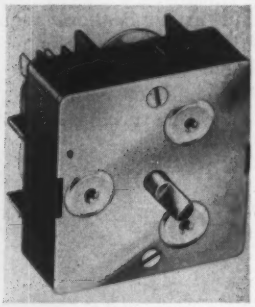
Dodge Torque-Arm is America's most widely used shaft mounted speed reducer. It is stocked by your local Dodge Distributor. Ask him. Or write us for bulletin.

DODGE MANUFACTURING CORPORATION, 3300 Union, Mishawaka, Ind.

DODGE

of Mishawaka, Ind.

Circle 560 on Page 19



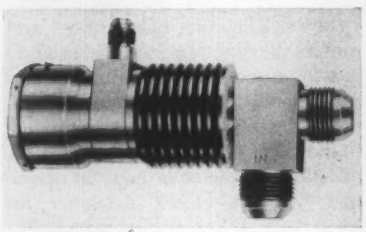
phenolic, offering rigid, dust-tight construction that assures reliable performance under adverse ambient conditions. Switch is rated at 28 amp or 1 hp at 250 v ac. Unit is available for 120 or 240-v operation at 50 or 60 cps with intervals of 1, 5, 15, 30, 60, 120, and 180 min. **Haydon Div., General Time Corp.**, 245 E. Elm St., Torrington, Conn. B

Circle 733 on Page 19

Hydraulically Operated Valve

terminates combustion in gas generator

By rapidly lowering pressure in solid-propellant gas generators such as those used in rockets, hydraulically operated valve terminates com-



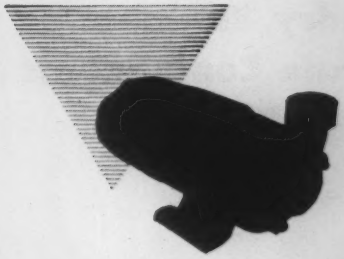
bustion in gas generator. No. 33-2258-000 valve can easily be modified to various line sizes and configurations. It can also be adapted to actuate a piston-cylinder or to modulate flow. **Aero Supply Mfg. Co. Inc.**, Corry, Pa. F

Circle 734 on Page 19

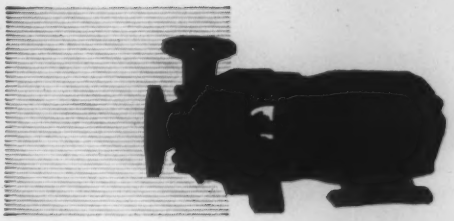
Steel Pintle Chain

for industrial and agricultural machinery

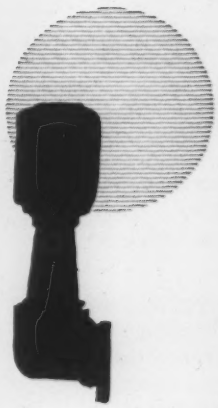
Steel pintle chain is designed for industrial and agricultural applications where cost, adverse operating conditions, low maintenance requirements, or use with cast sprockets are governing factors. It



get design flexibility



with I-R motorpumps



Simplify your problem of incorporating dependable pumping by selecting from Ingersoll-Rand's extensive line. No other manufacturer gives you a choice of so many types and sizes . . . no other pumps offer the same proven reliability and efficiency.

Motorpumps are available for sidewall, immersion or foot mounting. Get complete information now by writing for descriptive literature.

MOTORPUMP

by

Ingersoll-Rand

11 Broadway, New York 4, N.Y.

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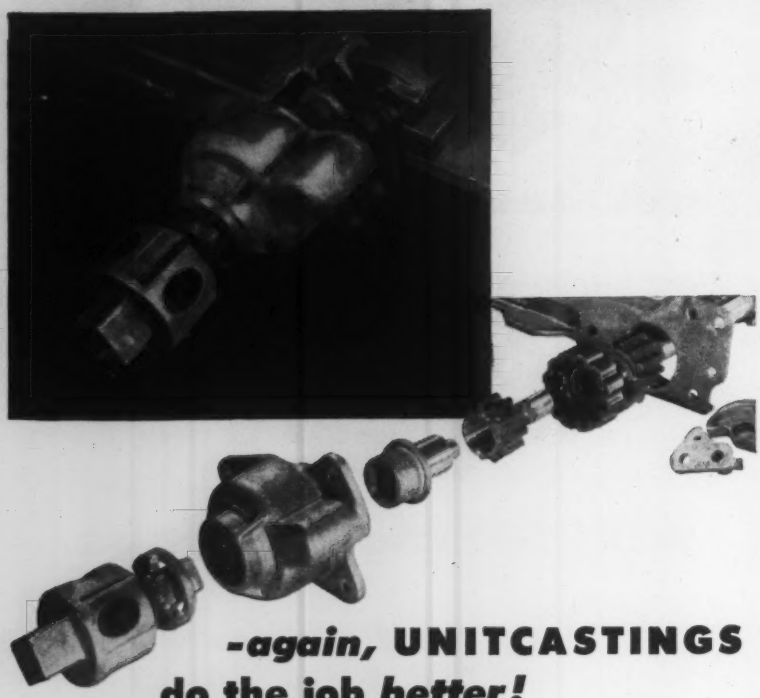
Circle 561 on Page 19

Progressive Foundry Engineering Develops Accurate Components . .



-again, UNITCASTINGS do the job *better!*

Unitcast foundry technicians, working hand-in-hand with customer's engineers, match new processes and developments with new steel casting demands.

The close tolerance requirements of this new horizontal gate mechanism proved a challenge. Designed around a new hypo-cyclic gear to reduce operating effort 80%, finished costs had to remain competitive. Each component was delivered to finished size with only touch up grinding necessary before assembly, and a high quality, durable product was marketed with the benefit of cast steel.

Unitcast offers similar service to help you with close tolerance, cost reducing problems. Write or call today for complete information.

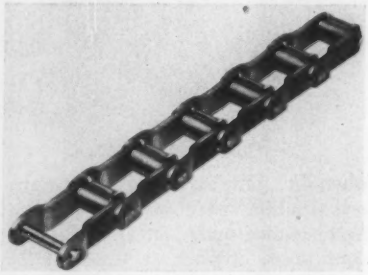
UNITCAST CORPORATION, Toledo 9, Ohio

In Canada: CANADIAN-UNITCAST STEEL, LTD., Sherbrooke, Quebec

Unitcast

SPECIFICATION STEEL CASTINGS

is useful in applications requiring capacities exceeding those of steel detachable chain where more costly roller chain or malleable pintle chain might be specified. Produced



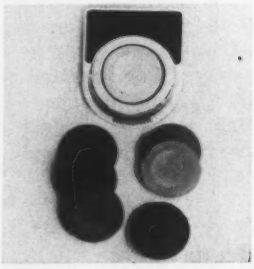
in four sizes, 662, 667, 667-H, and 672, to standard steel detachable-chain pitches, chain is formed to exceptionally close dimensions and uniform pitch from high-tensile, heat-treated steel. Attachment links are available for use in conveying applications. **Locke Steel Chain Co.**, 1230 Sabine St., Huntington, Ind. J

Circle 735 on Page 19

Oiltight Pushbuttons

project 3/8 in. in front of panel

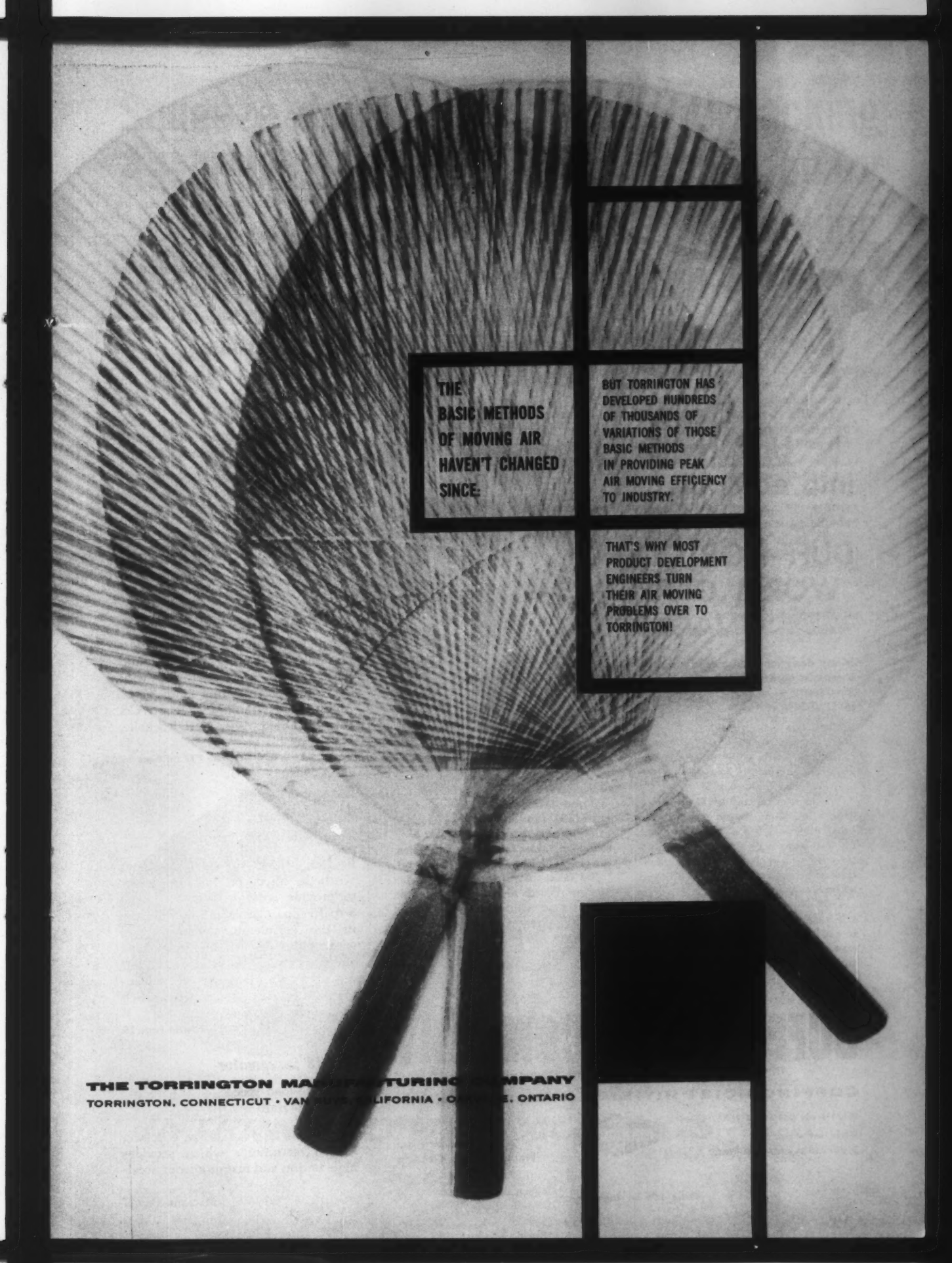
Low-silhouette Oil-tite pushbuttons, Type OT2, consist of operators and contact blocks, and can be used to control any electrical machinery and equipment. Features include minimum projection in front of panel, shallow contact block behind panel, interchangeable color caps on operators, contact blocks designed for



multiple stacking, and angled wiring terminals for easy wiring even when stacked. Pushbuttons measure 1 1/4 in. from front of panel to back of one contact block, with projection of 3/8 in. in front of panel. Contact blocks are 3/4 in. deep, 2 1/32 in. wide, and 1 7/8 in. high over terminals. Multiple stacking of blocks

Circle 562 on Page 19

Circle 563 on Page 19→


THE BASIC METHODS OF MOVING AIR HAVEN'T CHANGED SINCE:
BUT TORRINGTON HAS DEVELOPED HUNDREDS OF THOUSANDS OF VARIATIONS OF THOSE BASIC METHODS IN PROVIDING PEAK AIR MOVING EFFICIENCY TO INDUSTRY.
THAT'S WHY MOST PRODUCT DEVELOPMENT ENGINEERS TURN THEIR AIR MOVING PROBLEMS OVER TO TORRINGTON!
THE TORRINGTON MA TURING MPANY
TORRINGTON. CONNECTICUT · VA LIFORNIA · O E. ONTARIO

Design Uniform lift into equipment with DUFF-NORTON WORM GEAR JACKS

Many designers find a ready answer to precise control of linear motion in machinery or equipment with built-in Duff-Norton Worm Gear Jacks.

They are used singly, in tandem and in multiple jacking arrangements to position loads weighing from a few hundred pounds to as much as several hundred tons.

When connected in tandem or groups of four, six or more, these jacks always raise or lower in exact unison regardless of load distribution. They are also used for application of pressure, to push or pull and as linear actuators.

Duff-Norton Worm Gear Jacks are self-locking and will hold heavy loads in position indefinitely without any creep. Since there is no fluid or air to leak, the action is always positive and maintenance is no problem.

These jacks are available in eight standard models with capacities ranging from 2 to 100 tons and with standard raises from 6 to 24 inches. Special raises can also be furnished.

To learn more about how Duff-Norton Worm Gear Jacks may be used in your equipment, send for the bulletin which shows engineering drawings of jacks, Duff-Norton Mitre Gear Boxes and typical applications. Ask for AD-66v.

DUFF-NORTON COMPANY

P. O. Box 1889 • Pittsburgh 30, Pennsylvania

COFFING HOIST DIVISION • Danville, Illinois

DUFF-NORTON JACKS
Ratchet • Screw
Hydraulic • Worm Gear

COFFING HOISTS
Ratchet Lever • Air
Hand Chain • Electric

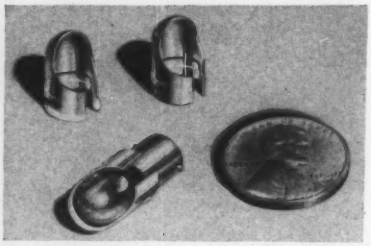
behind operator permits control of several operations simultaneously. Each contact block has two individual nylon push rods and circuits for electrical isolation of control circuits. Pushbuttons and enclosures prevent passage of oil, coolant, cutting oil, or water. **Westinghouse Electric Corp.**, P. O. Box 2099, Pittsburgh 30, Pa. F

Circle 736 on Page 19

Metal Lamp Shields

in straight and flared styles

All-metal lamp shields for T-3 ¼ lamp used in pilot lights and other instrument lighting are now available. Of spring-type brass, cadmi-



um plated, they fit directly on glass portion of lamp. Straight and flared styles are furnished, with aperture for controlling lamp beam. **Amatom Electronic Hardware Co. Inc.**, 88 Drake Ave., New Rochelle, N. Y. D

Circle 737 on Page 19

Filter Cartridge

offers filtration through micron range

Feutron filter cartridge employs synthetic fibers of varying denier to provide accurate filtration from 5 to 75 mu. Cartridge has wide use in the petroleum, chemical, and other industries where filtration of aqueous liquids is needed. It has life up to six times that of conventional filter cartridges. **American Felt Co.**, Glenville, Conn. B

Circle 738 on Page 19

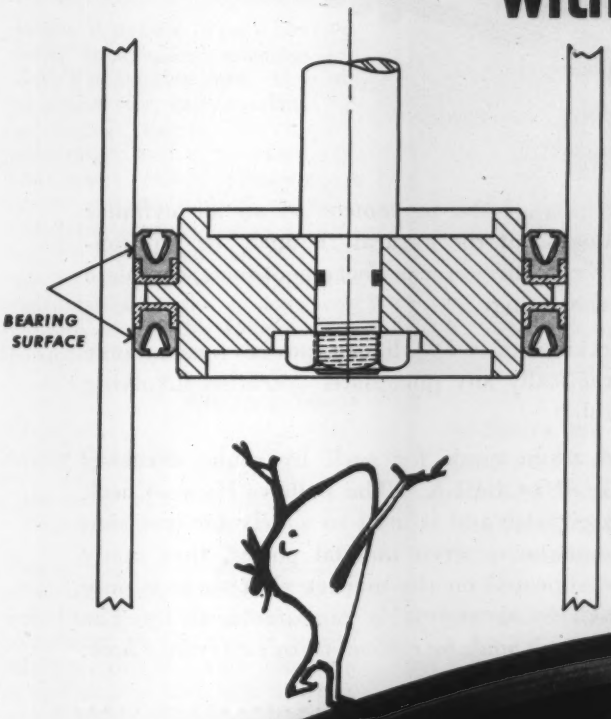
Size-18 Servomotor

has no-load speed of 3200 rpm

No. 18 SM 691 is a 115-v, 60-cycle, size-18 servomotor which provides high torque and instantaneous accel-

Circle 564 on Page 19

Squeeze down on expensive U-Packing Assemblies . . . with IPC's revolutionary "GUIDE-U-PAK"*. . . the packing with a built-in bearing!



A new engineering concept for hydraulic systems sealing! . . . IPC's GUIDE-U-PAK is a bonded case U packing that really puts the squeeze on expensive, complex U packing assemblies. Follower plates or back up plates with their high cost drilling, machining and fitting are eliminated. *Moreover,* GUIDE-U-PAK supplies its own bearing . . . riding smoothly on a close tolerance brass**case. You can end the practice of machining a wear sleeve on the piston surface, too! GUIDE-U-PAK is press fitted on the piston.

The "custom approach" in packings and seal manufacture, which typifies all IPC products, has brought this development through extensive testing. Precise manufacture means that you can specify critical tolerances for both ID and OD measurements or we will be glad to analyze your problem . . . recommend specific sizes. By establishing these limitations you can be assured of exact bearing surface and press fit.

For your next hydraulic sealing problem investigate GUIDE-U-PAK. You'll be pleasantly surprised!

OIL SEALS / PACKINGS / PRECISION MOLDING

Custom designed for your application . . .

IPC

*PATENT PENDING

**Other materials are available. Write for details.

INTERNATIONAL PACKINGS CORPORATION

Bristol, New Hampshire

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P-6

IF IT ISN'T MADE BY BELLOWS . . .

it isn't a HYDRO-CHECK*

*TM Registered U.S. Patent Office. No. 527,974

Hydraulic checking of the movement of an air cylinder piston rod smooths out the natural "bounce" or "springiness" of air—gives to air power perfect smoothness, complete freedom from chattering.

Hydraulic checking of air cylinder power has become standard in practically any pneumatic operation involving precision control.

Our registered trade mark for such hydraulic checking devices is "HYDRO-CHECK." The Bellows Hydro-Check has become so popular and is used so widely for precision control of pneumatic or even manual power, that many imitators have appeared on the market—but there is only one HYDRO-CHECK and it is manufactured by The Bellows Co. *If it isn't made by Bellows it isn't a Hydro-Check.*

OTHER REGISTERED TRADE MARKS OF THE BELLOWS CO.

THE BELLOWS AIR MOTOR — the air cylinder with the built-in valve and operating controls.

THE SUPER-SPEED AIR MOTOR — the air cylinder with twice the speed — twice the power.

ELECTROAIRE — the electrically controlled four-way valve for integral mounting on the Bellows Air Motor or for remote control of any air cylinder of suitable capacity.

PULSA-PAK — an electrical control device to permit maintained circuits yet provide a momentary electrical impulse.

SENSITORQUE — a torque-sensing unit for control of deep hole drilling operations.

CARBI-DRILL — heavy-duty drill unit.

LUBRI-AIR — a unit to filter, pressure regulate and lubricate compressed air.

POWER-DOME — plain air cylinders featuring dome head construction.

1493-B

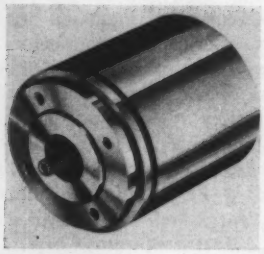
Would you like to know more about the many models and sizes of Bellows Hydro-Checks? What they are — how they work — how you can use it to obtain precision control of air cylinder movement? Write today for Bulletin HC-600R. Address Dept. MD1059, The Bellows Co., Akron 9, Ohio.

The Bellows Co.

DIVISION OF INTERNATIONAL BASIC ECONOMY CORPORATION (IBEC)

AKRON 9, OHIO

OTHER INDUSTRIAL DIVISIONS OF IBEC: Sinclair-Collins Valve Co., Valvair, Akron, Ohio • V. D. Anderson Co., Cleveland, Ohio



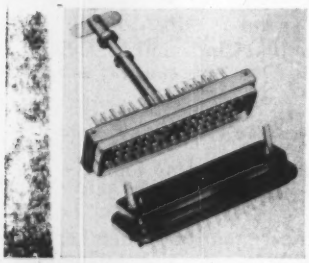
eration. Weighing 15 oz, it has completely encapsulated windings and housing of stainless steel. Unit can be wound for any standard carrier voltage supply, and requires power input of 9 w per phase with 0.64 power factor. Performance figures include no-load speed of 3200 rpm, torque at stall of 4 oz-in., and acceleration at stall of 70,000 rad per sec per sec. It operates continuously at stall to unit temperature of 200 C. **Helipot Div., Beckman Instruments Inc.**, 2500 Fullerton Rd., Fullerton, Calif. L

Circle 739 on Page 19

Power Connectors

miniature units are for heavy-duty applications

Four series of miniature power connectors are designated GA, E-Z, 14, and 16. They are available for heavy-duty applications in guided missiles, aircraft, and electronic equipment requiring high dielectric and mechanical strength combined with high precision and reliability. Series GA, illustrated, has 52 contacts and spring - action center



screwlock to permit fast engagement and disengagement. Series is also available in 10, 32, 35, 40, and 48 contacts. Series 14 and 16 are compact, heavy-duty rectangular connectors with current rating of 10 amp and voltage breakdown of 4500-4700 v rms at sea level. They are available in 7, 9, 10, 15, 18, 19, and 20 contacts with turret,

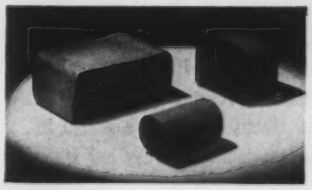
Stalwart Announces

SILICONE SPONGE RUBBER...

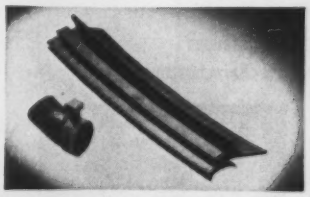
in extruded and calendered shapes

Exclusive new processes produce cross sections, lengths and densities to your specifications

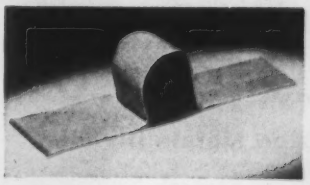
s302-SR



Cell sizes range from very coarse to fine with open or closed cell-structures.



Silicone sponge extrusions can be combined with solid silicone rubber extrusions.



Calendered and extruded silicone sponge shapes can be covered with heat-resistant fabric.

Here is important news for designers in the appliance, aircraft, electronics and other industries! A unique process developed by The Stalwart Rubber Company now enables silicone rubber to be extruded and sponged in complex configurations or calendered to close tolerances to meet customer specifications. Here are the facts... Stalwart extrudes silicone sponge parts in 1/16 to 8-inch dimensions in lengths up to 300 feet. Calendered sheets are produced in widths up to 36 inches. These silicone sponge parts resist sunlight, ozone, and aging as well as temperatures ranging from −160° to +500° F. Stalwart also mass-produces all types of precision parts from natural and synthetic rubbers.

Send today for your copy of the new Stalwart Catalog.

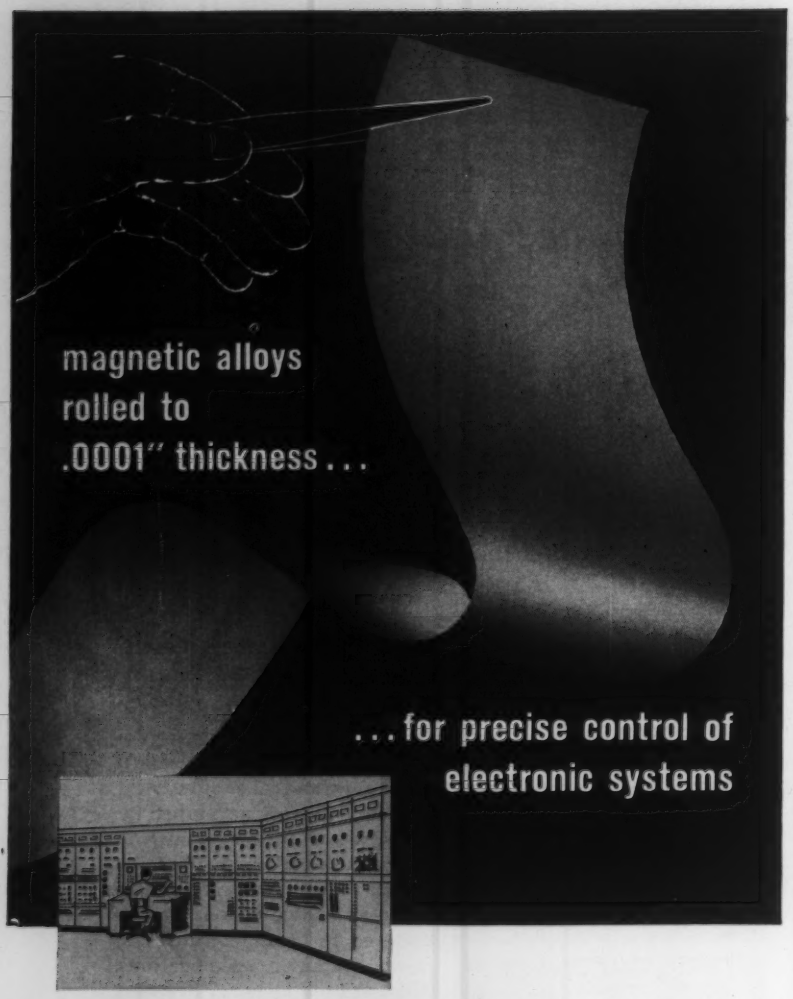
Another first by

STALWART RUBBER COMPANY

180 NORTHFIELD ROAD • BEDFORD, OHIO

PLANTS in BEDFORD, OHIO and JASPER, GEORGIA.

Circle 567 on Page 19

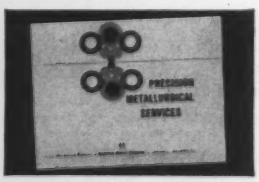


Now you can obtain high magnetic permeability alloys such as 4-79 Moly Permalloy, Alfenol, and HyMu "80" in cold rolled strip and foil in **production** quantities! The unique and newly expanded facilities of Precision Metals Division are geared to produce ultra-thin metal strip and foil in any quantity and in virtually any alloy.

Precision Metals strip and foil for development and production offer these special advantages:

uniform magnetic properties
thicknesses from .010" to .0001"
dimensional uniformity
extremely close tolerances
excellent surface characteristics

For specific requirements, Precision Metals can also furnish custom alloys to your own specification in the form you need. Write today for fully illustrated facilities booklet, MD-10.



HAMILTON
WATCH COMPANY / **Precision Metals Division**
Lancaster, Pennsylvania

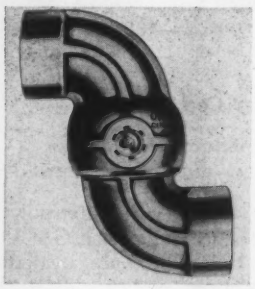
solder-cup, or taper-pin terminations. Series E-Z connectors have individually spring-loaded pin contacts, featuring quick release with practically no disengagement force and low insertion force. They have polarizing screwlocks and aluminum hoods. Five molding compounds are furnished. **Electronic Sales Div., DeJur-Amsco Corp.,** 45-01 Northern Blvd., Long Island City 1, N. Y. D

Circle 740 on Page 19

Swing Joints

for 1000 psi service

Stainless-steel swing joints are used as elbows in pipe lines wherever flexibility and rigidity are both needed. They easily withstand tough, corrosive conditions and prevent contamination. Series 7400



swing joints are available in 1¼ to 4-in. sizes in 17 styles. Cast in 316 stainless steel and designed for 1000 psi service, they have O-ring seal which determines service temperature. O-rings are available in Viton, Buna-N, neoprene, butyl, and Teflon. **OPW-Jordan,** 6013 Wiehe Rd., Cincinnati 13, Ohio. G

Circle 741 on Page 19

Panel Wireway

with independent top, bottom, and sides

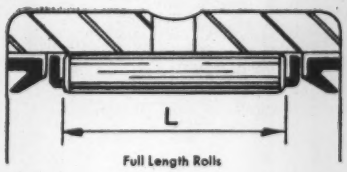
Electrical control panels can be wired efficiently and quickly with modular panel wireway system. Independent top, bottom, and sides are furnished for flexible adaptability to every job. Wire lacing and bundling are eliminated, and neat-appearing finished job permits convenient wire inspection and simplified method for adding or removing wires. Wireway meets JIC requirements. Tough plastic mate-

Circle 568 on Page 19

More Load Capacity! More Design Flexibility!

ORANGE SEALED *Cage Type* NEEDLE BEARINGS

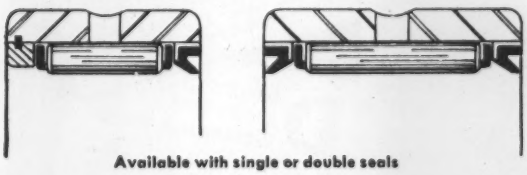
Longer Rolls—Higher Capacity



Full Length Rolls

Only Orange construction provides effective sealing without reducing roll length or load carrying capacity. Note the proportion of roll length to race, compared with other types. You get the full load capacity of Orange Cage Type Needle Bearings—plus the economy and efficiency of built-in Neoprene seals to keep dirt out and lubricant in.

TWO Bearing Lengths for Design Flexibility



Available with single or double seals

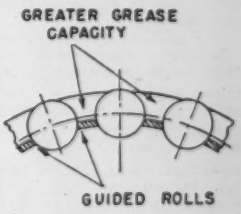
Only Orange offers Sealed Cage Type Needle Bearings in TWO bearing lengths for each shaft diameter. Both bearing lengths have full-length rolls in proper proportion to race, providing maximum load-carrying capacity. Thus, you have greater flexibility in meeting load, space and design requirements. Other sealed needle bearings offer only one bearing length, with shorter rolls and less capacity.

Effective Seal Design →

This provides positive exclusion of foreign matter, retains lubricant and acts as a vent to prevent displacement of seal if additional lubrication is added through holes provided in races.

—plus advantages of Orange Cage Design

The Orange cage design assures constant contact with entire length of roll periphery to provide the ultimate in guided rolls and resistance to skewing. Adequate space around rolls provides exceptional capacity for lubrication.



Stocked in popular sizes from ½" to 4" shaft diameters. Other sizes will be added as volume requirements are established.

Write for new, detailed brochure giving engineering data, construction, dimensions, etc.

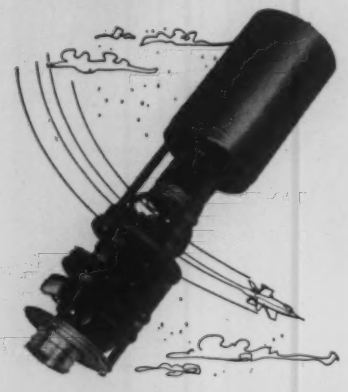
ORANGE ROLLER BEARINGS

ORANGE ROLLER BEARING CO., Inc.
556 Main Street, Orange, N. J.

Needle Bearings — Staggered Roller Bearings
Journal Roller Bearings — Thrust Roller Bearings
Cam Followers

SPECTROL PRECISION MECHANISMS

Pilot to Cockpit to Control



When a test pilot rockets into the outer atmosphere for the first time driving experimental craft such as North American's X-15, he'll feel as though he's been there before.

Before his first actual flight, the pilot trains for many hours in "dry land" rocket craft. There, he learns to cope with upper atmosphere problems as posed by an analog computer. Every time he touches a control, the computer responds and the result appears on the instrument panel in the training cockpit. The entire bank of instruments reacts as though he were really "up there." In this way, the pilot meets every conceivable situation long before he takes his powerful bird aloft.

And what does Spectrol have to do with this important training program?

Spectrol makes the link that joins the computer and the bank of instruments in the cockpit. This link, known as a servo repeater, translates the computer's information into meaningful dial readings. As you know, such information must be transferred quickly and accurately.

Spectrol servo repeaters do just that. Key specifications for a typical unit now in production are:

Maximum velocity: 360°/sec
Acceleration in excess of 7000°/sec²
Static accuracy better than 0.25 deg. at output shaft

Other applications for Spectrol packaged servo repeaters include dial drives on GCA equipment, airborne computers and dc systems in general.

Spectrol PRECISION MECHANISMS free the systems engineer from building functional sub-assemblies. If you need precise logical system modules combining in a *single specification* sub-assemblies using components such as gear drives, clutches, precision potentiometers and servomotors —Spectrol can help.

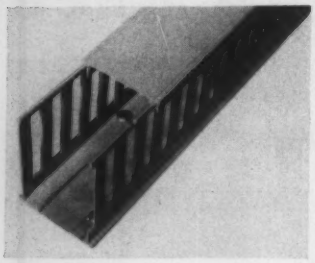
For complete information, call your nearest Spectrol engineering sales representative, or address Dept. 5710-A.

14

SPECTROL

ELECTRONICS CORPORATION
1704 SOUTH DEL MAR AVENUE • SAN GABRIEL, CALIF.

Circle 570 on Page 19



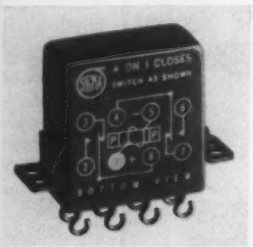
rial is flame resistant, has excellent insulating qualities, and is dimensionally stable. System consists of complete panel wireway preassembled from independent sides and base of proper width. Unit can be disassembled at any time and converted to a different size. Side pieces can be slid into tracks in base to make up ducts in any width or size. When mounted on panel, mounting screws pass through both sides and base, permanently attaching them together. **ECP Corp.**, 4726 Superior Ave., Cleveland 3, Ohio. F

Circle 742 on Page 19

Subminiature Relay

withstands 30 g vibration to 5000 cycles

Subminiature, polarized DPDT relay uses magnetic latching to eliminate need for stand-by power and to increase operating life. Series 32 is hermetically sealed, measures 0.8 x 0.4 x 0.9 in., and weighs only 18 gm. Particularly useful in military



applications, unit has vibration rating of 30 g to 5000 cycles. Available with either single or dual coils, relay has standard operating sensitivities of 50 mw for single coil and 100 mw for each coil of dual-coil type. Operating temperature range is −65 to +125 C. Operating time ranges from 2 to 20 millisec, depending on overdrive. Contact rating is 2 amp for silver contacts and 0.5 amp for gold-alloy contacts, rec-

Here's Your ABC's ON THE NEWEST ROTARY PUMPS

A SERIES LOW TO MEDIUM VISCOSITY

High speed units to pump 3 to 25 g p m . . . low speed units 20 to 90 gpm. Maximum operating pressures to 100 psi. Gear, V-Belt or direct drives.

B SERIES HAZARDOUS LIQUIDS

Sealed units U. L. Approved. High speed pump up to 23½ gpm . . . low speed pump to 90 gpm. Maximum U.L. pressure rating for hazardous fluids 50 psi. Gear, V-Belt or direct drives.

C SERIES RUGGED DUTY MEDIUM-HIGH VISCOSITY

Continuous operation packed pumps. Heavy outboard thrust bearing. Pump up to 211 gpm at pressures to 125 psi. Gear, V-Belt and direct drives. Threaded or flanged ports. Also Series "E" steamjacketed pumps.

D SERIES RUGGED DUTY MECHANICALLY SEALED

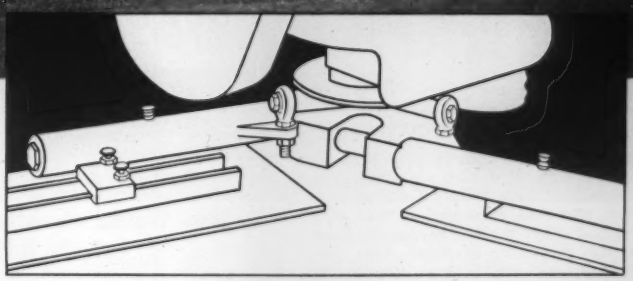
For broad group of liquids of wide viscosity range. Pump up to 211 gpm @ 450 RPM. May be operated at pressures to 100 psi. Gear or gear-motor drives. Threaded or flanged ports.

Wayne PUMPS

THE WAYNE PUMP COMPANY
Industrial Division
FORT WAYNE 4, Indiana
Division of Symington Wayne Corporation

Circle 571 on Page 19

HEIM
Unibal®
ROD ENDS



Unibal Spherical Bearing Rod End — Male

For Positive Control of Tilting Action

The blades of the Stow Roto-Trowel tilt to the required pitch for finishing new concrete surfaces. Turn up the control knob on the handle to push down on the tilting plate for a higher angle of the arms and blades. This action requires a self-aligning bearing which must transmit a thrust load and rotate at the same time. Selected by the Stow Mfg. Co. of Binghamton, N. Y., as the perfect connection between the actuating rod and the pivoting and rotating blade arms was the **Heim Unibal Spherical Bearing with Sintered Iron Ball.**

Here is another simple but ingenious application of the Heim Rod End in a mechanical linkage where an improvement in the operation has been accomplished. Combined in a comparatively small unit are all the elements necessary for trouble-free, peak performance:

- Load ratings more than adequate for the job.
- Self-lubrication in the sintered iron ball, with an oil capacity 20% of its own volume.
- Correction of misalignment inherent in the motions of the blade arm and control rod.
- Quick and easy installation at low cost.
- Long life under rough, exposed conditions.
- Replaceable without complete disassembly of the machine.

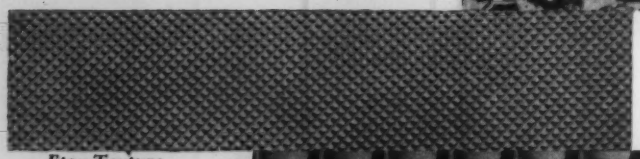
All Heim bearings are available through the leading bearing distributors in the U. S. and Canada. Send for complete catalog with distributors' names and locations.

THE HEIM COMPANY
FAIRFIELD, CONNECTICUT

ARDMORE TEXTURED METALS

give you . . a PLUS factor

Leeds Texture



Eton Texture

Oxford Texture

There's more to Textured Metal than meets the eye! Sure, distinctive appearance is important . . . it attracts customer interest and adds buy-appeal, but Ardmore Textured Metal gives you a *plus* factor . . . it's functional, too.

The three-dimensional surface sheds wear and abuse — adds years to product life and minimizes costly rejects during fabrication. Increased strength often permits gauge reductions which save you material, weight and money. That's not all . . . controlled light diffusion, non-skid, increased surface area for heat transfer or dissipation, acoustical and many more inherent qualities make Ardmore Textured Metal the practical designer's material. Also consider the great latitude of design change possibilities (without accompanying high tooling costs) offered by the wide selection of stock Ardmore textures and finishes. Doesn't it make sense to you that a material with the *plus* factor offered by Ardmore Textured Metal . . . bears investigation?

Available in *all* metals, any finish, solid or perforated. Eight new exciting textures in sheets up to 52" in width or continuous coils to 48" width. Multiples, blanks or finished parts are furnished to your specifications. Ample inventory and modern high-speed equipment assure you prompt service — economical pricing.

Send today for this new 6 page brochure which describes in detail all of the textures and finishes available together with photos of production applications in all industries.

ARDMORE PRODUCTS, INC.

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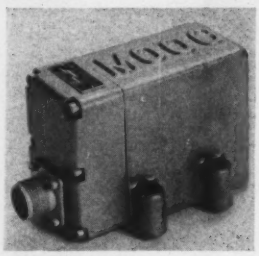
ommended for dry-circuit operation. Various mounting styles are available. **Sigma Instruments Inc.**, 170 Pearl St., South Braintree 85, Mass. B

Circle 743 on Page 19

Industrial Servo Valves

for system pressures from 500 to 4500 psi

Series 71 high-performance industrial servo valves find application in a wide range of industrial hy-



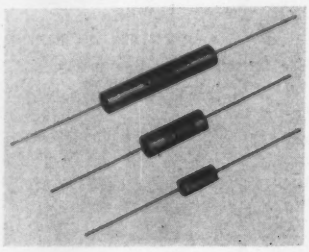
draulic-servo control systems. They offer reliability and ruggedness of industrial components and have performance typical of aircraft-type units. Valves are available from stock in 1, 2.5, 5, and 10-gpm rated flow at 1000 psi valve pressure drop and 15 ma input current. They operate at system pressures from 500 to 4500 psi. **Industrial Div., Moog Servocontrols Inc.**, East Aurora, N. Y. N

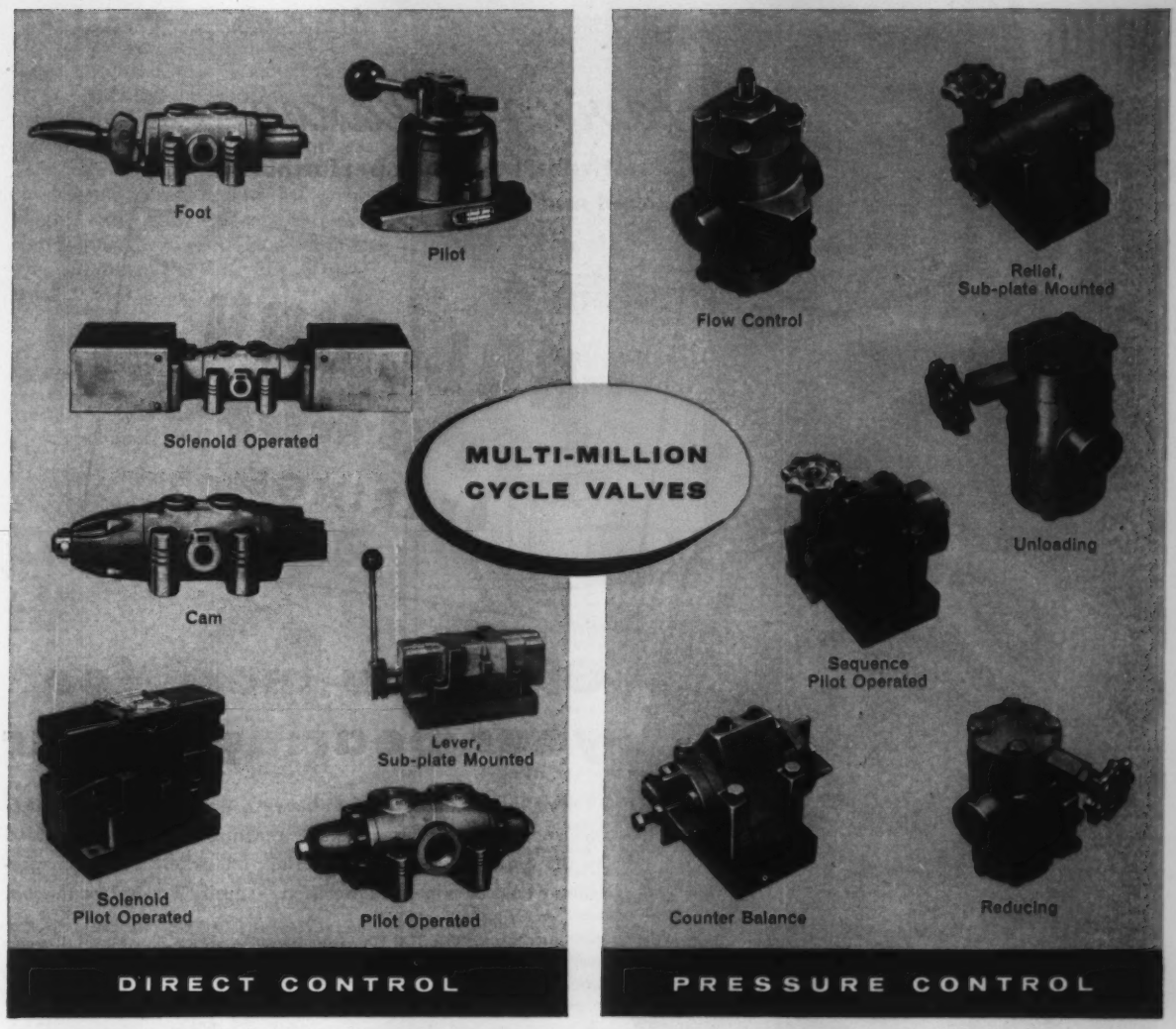
Circle 744 on Page 19

Wire-Wound Resistors

are small-size units for high temperatures

Molded wire-wound resistors are supplied in precision tolerances. Ratings at 25 C are 3, 5, and 10 w, and at 200 C ratings are still sizable —1, 1.5, and 3 w respectively. At this ambient and higher, units perform to all requirements of MIL-R-9444 yet are substantially smaller than ¼, 1, and 2-w sizes (at 125 C ambient) listed under this mili-





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Whatever your requirements, you can find the right valve at Rivett. Save time, money, inventory and maintenance with these most advanced designs. Greater flow capacity; minimum pressure drop; positive damping and operating stability. From single basic assembly of functional valve any one of six functions may be obtained. Over 400 standard models—sub-plate and pipe mounted; direct control and functional. Pressures 1500 and 3000 P.S.I. All actions, all piston designs, all operations. Sizes ¼" to 2". J.I.C. standards.

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Cat.'s 204, 210, 230 and 261 contain 68 pages describing all valve models, sizes and types with complete working drawings, specifications, performance, ratings, cut-away views. Get free copies today.

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HYDRAULIC VALVES

For a money-saving balance

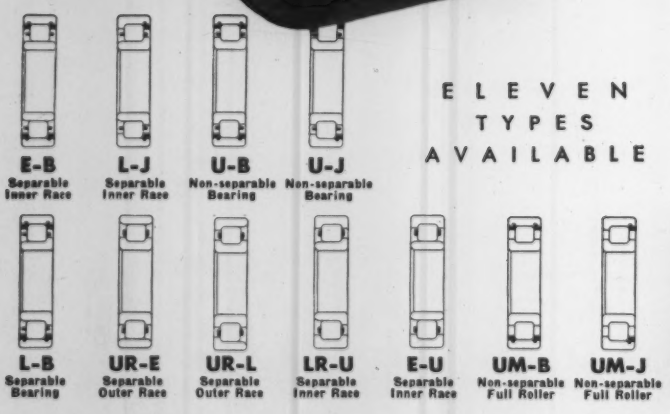
between maximum performance and moderate cost . . .

ROLLWAY Tru-Rol® BEARINGS

Give you more for your bearing dollar

For those hundreds of in-between applications where performance requirements are more exacting than those provided by the ordinary commercial bearing, but where maximum precision would be unneeded precision — specify Tru-Rol for the job.

Tru-Rol Bearings provide above-commercial-grade efficiency . . . at worthwhile savings in cost. Internal clearances are closely controlled. Rollers are equally spaced to eliminate out-of-balance vibration. Each roller is crowned to distribute the load evenly along the full length of the roller. Eleven types available in single and double width bearings, in stamped steel retainer, segmented retainer or full roller construction.



ELEVEN TYPES AVAILABLE

Ask your nearby Rollway Service Engineer to detail the quality you *should be getting* in your "commercial grade" bearings. Or write for the Rollway Tru-Rol catalog showing the full line, and capacity and size ranges. ROLLWAY BEARING COMPANY, INC., Syracuse, N. Y.

ROLLWAY® BEARINGS

COMPLETE LINE OF RADIAL AND THRUST CYLINDRICAL ROLLER BEARINGS

ENGINEERING OFFICES: Syracuse • Chicago • Toronto • Cleveland • Seattle • San Francisco • Boston • Detroit • Pittsburgh • Houston • Philadelphia • Los Angeles

Circle 575 on Page 19

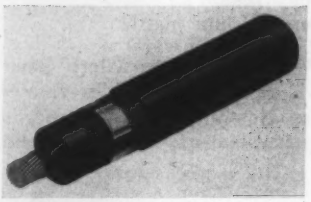
tary specification. They exhibit great stability of resistance and temperature coefficient even at maximum operating temperature of 275 C. Resistors are wound helically on ceramic cores, and a jacket of tough, resilient, silicone-ceramic material is pressure-molded around core. **Ohmite Mfg. Co.**, 3657 Howard St., Skokie, Ill. J

Circle 745 on Page 19

Power Cable

has 33/64-in. thick butyl-rubber insulation

New 28-kv power cable is used as primary lead cable for generators, transformers, and other distribution equipment. The 33/64-in. thick



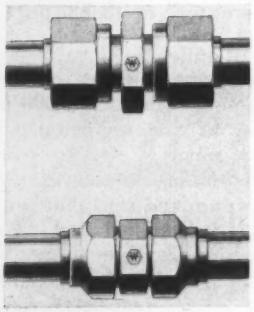
butyl-rubber insulation sustains increased physical and electrical demands placed upon cable. Cable, in addition to heavy insulation, has 7/64-in. neoprene outer jacket. It has an OD of 2.3 in. and weighs 3.6 lb per ft. **National Electric Div., H. K. Porter Company, Inc.**, Porter Boulevard, Pittsburgh 19, Pa. F

Circle 746 on Page 19

Flareless Fittings

are of titanium alloy

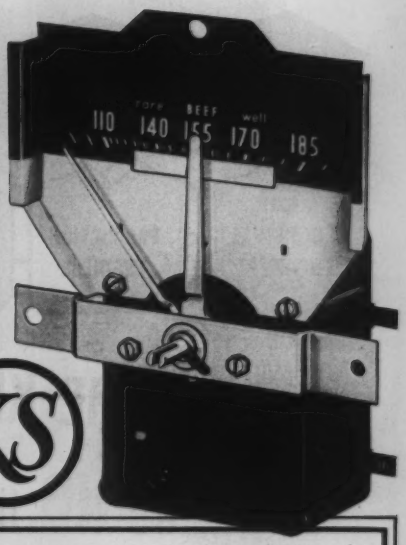
New flareless fittings combine advantages of very light weight, extreme compactness, and reliability over wide temperature range. Fittings offer advantages on all aircraft and missile fluid systems. They



Chace Thermostatic Bimetal

ACTUATES ANOTHER PRECISION PRODUCT...

KS



THE KING-SEELEY ROAST CONTROL

A product of King-Seeley Division, King-Seeley Corporation, Ann Arbor, Michigan

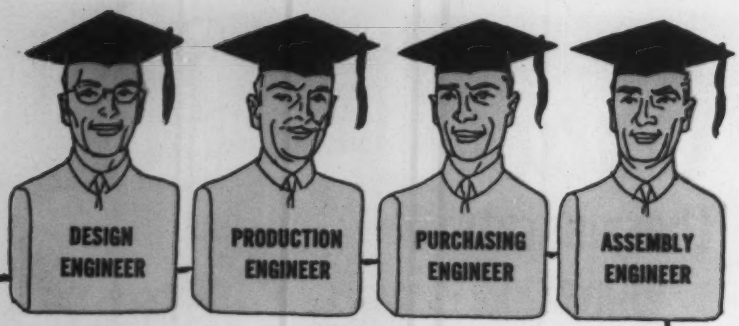
The King-Seeley Roast Control was introduced on 1959 Westinghouse ranges as their "Serv-Temp Roast Guard" with the slogan "Never again a ruined roast." It controls inside meat temperatures so that when the roast is done — rare, medium or well done — as you like it, the oven heat is brought down to inside meat temperature holding the roast, juicy, flavorful, oven hot, for hours if necessary regardless of how long a dinner may have to be delayed. Three elements of Chace Thermostatic Bimetal are used. The indicator bimetal accurately shows inside meat temperature and starts the control function anticipating the desired degree of doneness. The responder bimetal uses this information to control the oven thermostat. The voltage regulator bimetal provides a constant voltage supply to the system.

Triple responsibility is evident here — and all dependent on those three small bits of Chace Thermostatic Bimetal. The manufacturers of appliances to whom King-Seeley sells have a vast responsibility to millions of customers all over the world. They must not permit their products to misfunction or malfunction, regardless of abuse or lack of attention. King-Seeley has a fine old reputation to maintain as a major supplier of dependable controls and indicators. Chace produces the critical bits of metal on which the two may safely base their claims as leaders in their fields. It's natural that such buyers go where history indicates they'll get the finest precision bimetal available — where a third of a century of production and development experience back up every fraction of an ounce.

While your new temperature actuated device is in the preliminary design stage, send for our booklet, "Successful Applications of Chace Thermostatic Bimetal." It's full of design engineering data with illustrated examples of uses of bimetal. Remember, too, that our precision product is available in strips, coils or completely fabricated elements of your design.

W. M. CHACE CO.
Thermostatic Bimetal
1616 BEARD AVE., DETROIT 9, MICH.

Circle 576 on Page 19



THOSE IN THE KNOW, KNOW

There's NO time waste

There's NO machining

There's NO grinding

There's NO counting

There's NO stacking

There's NO miking

and there's NO dirt between layers—ever, for those who say

YES to...

Laminated Shims of LAMINUM now available in

LAMINUM®
the solid Shim that p-e-e-l-s for adjustment

Send for free copy "Engineering Data File"

STAINLESS STEEL	ALUMINUM	BRASS	MILD STEEL
with laminations of .002" or .003"	with laminations of .003" or NEW .002"	with laminations of .002" or .003"	with laminations of .002" or .003"

LAMINATED SHIM COMPANY, INC.

EAST COAST Home Office and Plant
1210 Union St., Glenbrook, Conn.

WEST COAST Sales Office
600 Sixteenth St., Oakland 12, Calif.

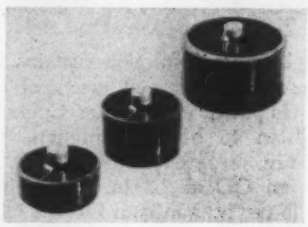
have been successfully tested per MIL-F-18280A at temperatures from −65 to +600 F on hydraulic applications and from −300 to +200 F for liquid oxygen and gaseous applications. Fittings are titanium alloy, with basic properties of high resistance to corrosion, low density, and high endurance strength over wide temperature range. Fittings are available in sizes -2 through -32 in union, 90-deg elbows, 45-deg elbows, and tee configurations. **Aircraft and Missile Group, Weatherhead Co.**, 300 E. 131st St., Cleveland 8, Ohio. F

Circle 747 on Page 19

Cartwheel Capacitors

incorporate an arc-resistant plastic

HV cartwheel capacitors have a wide range of capacities and voltages. Newly developed plastic, having excellent arc-resistant properties



and high corona-starting voltages, has been incorporated in the units. Thick-disc dielectric types which give dependable service in flyback circuits are available in rated voltages of 6, 10, 12, 15, 20, 25, and 30 kv in wide range of capacities and with three different terminal variations. **Hi-Q Div., Aerovox Corp.**, Olean, N. Y. N

Circle 748 on Page 19

Relief Valve

for pressures to 10,000 psi

Balanced-outlet relief valve accommodates air, nitrogen, or helium service in pressures to 10,000 psi at flows of 50 scfm minimum. Temperature range is −65 to +275 F, and zero leakage is assured. Valve is aluminum and steel, but can also be made in stainless steel. **Vinson Engineering & Sales Corp.**, 8044 Woodley Ave., Van Nuys, Calif. L

Circle 749 on Page 19

Circle 577 on Page 19

Design Now, for Automatic Protection of Machine Bearings . . .

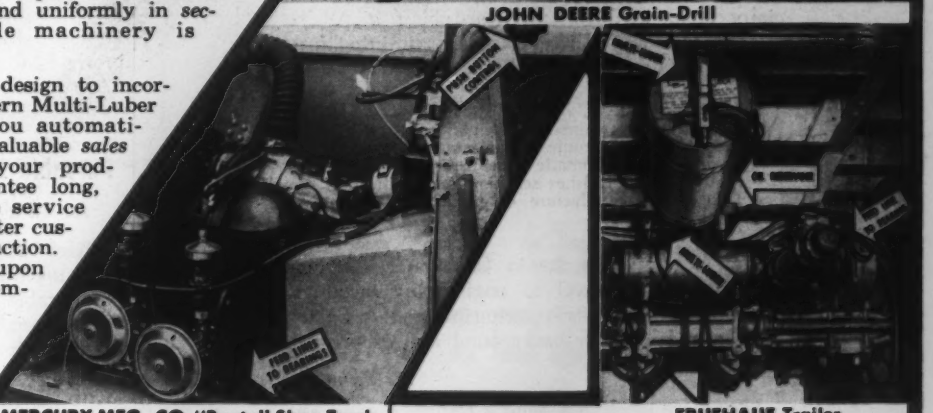
WITH LINCOLN LOW-COST Multi-Luber* CENTRALIZED SYSTEMS

Leading manufacturers in one industry after another are designing Lincoln Multi-Luber Centralized Lubrication into their products because these easy-to-assemble Systems provide positive, automatic metered lubrication to machine bearings at the lowest possible cost.

Multi-Luber Systems provide dependable, trouble-free bearing protection . . . reduce breakdowns and repairs. Systems are engineered and built to last the life of the machine itself. Lubricant is sealed against contamination. Lubricate all bearings—even loose-fitting or tight bearings and open chains—simultaneously and uniformly in *seconds*, while machinery is operating.

When you design to incorporate modern Multi-Luber Systems, you automatically add valuable *sales appeal* to your products, guarantee long, trouble-free service life for greater customer satisfaction. Mail the coupon now for complete design details.

DIAMOND MACHINE CO. Drill Press



JOHN DEERE Grain-Drill

MERCURY MFG. CO. "Banty" Shop Truck

FRUEHAUF Trailer

Lincoln

MAIL THIS COUPON TODAY!

LINCOLN ENGINEERING COMPANY
Division of The McNeil Machine & Engineering Co.
St. Louis 20, Mo.

*Trade Name Registered

LINCOLN ENGINEERING CO.
5736 Natural Bridge Ave.
St. Louis 20, Mo.

Please send my copy of Catalog No. 50 giving complete specifications on Lincoln Multi-Luber Systems.

NAME..... TITLE.....

COMPANY.....

ADDRESS.....

CITY..... ZONE..... STATE.....

Wanted: Engineers

with an interest in writing

Like to break into an interesting field where you'll make good use of your engineering talents — yet have a chance to develop new skills?

We're looking for several men with engineering experience and a yearning to write or edit. As an editor on MACHINE DESIGN, you would broaden your engineering background in a job that provides stimulating contact with people in many engineering areas.

You don't have to have actual writing or editing job experience, although we expect definite ability in handling the English language. An ME or EE degree plus several years of design-engineering experience would be ideal, but we'll be happy to consider equivalent qualifications. Age: 25 to 35.

If you've worked in a design-engineering specialty area, we'd like to hear about it. We're interested in any job experience or training in:

- Mechanical drives, controls, systems
- Mechanical components, assemblies
- Electrical or electronic drives, controls, systems
- Hydraulic or pneumatic systems, drives, controls
- Materials and finishes selection or specification
- Design for manufacture or production design

Our headquarters are in Cleveland. There is opportunity for travel to engineering meetings, expositions, and manufacturing companies. Salary will depend on your background and experience.

If you are interested, send a resume of your engineering background, and any evidence you may have of writing ability (we'll return this if you wish) to: Editor, MACHINE DESIGN, Penton Bldg., Cleveland 13, Ohio.

MACHINE DESIGN

ENGINEERING DEPARTMENT

EQUIPMENT

Dual-Range Power Supply

has low ripple at top load

Rack-mounted, dual-range dc power supply, known as Model EFBR, supplies a continuous variable-power source from 0 to 16 v for current loads to 8 amp, and from 0 to 32 v for current loads to 4 amp. Unit has less than 10 mv ripple at top load,

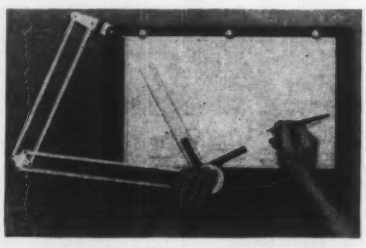
and is intended for operation from 117-v 60-cps supply source. Power supply is suitable for continuous, medium-duty operation in testing and servicing of transistor circuits, radios and electronic equipment in aircraft, autos, tanks, and marine craft, as well as relays and solenoids. **Electro Products Laboratories Inc.**, 4500 N. Ravenswood Ave., Chicago 40, Ill. I

Circle 750 on Page 19

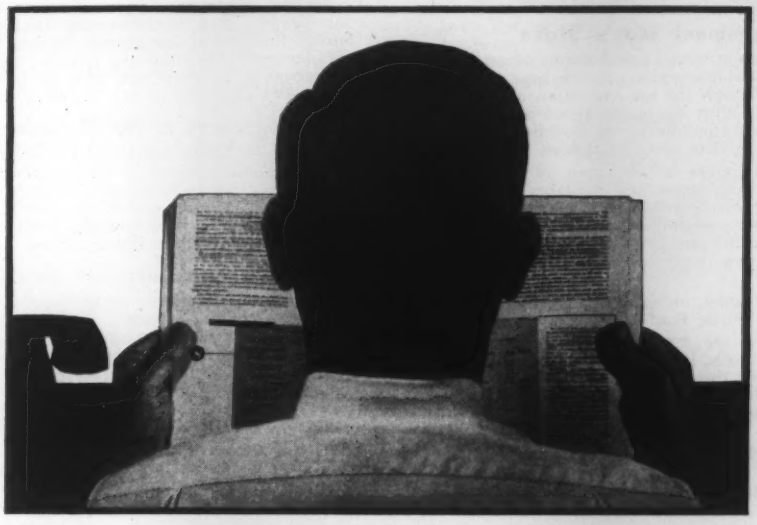
Portable Drafting Machine

for 12 x 18 drawing sheets

Model 112-M Drafto portable drafting machine consists of three demountable units—board, parallel-arm assembly, and protractor complete with scales. Masonite board, measuring 15 x 20 in., is equipped with three circular paper clamps which offer minimum interference to vertical scale. Unit accepts 12 x 18-in. drawing sheets. Four 13-



$1000 REWARD



For the capture of this man's ATTENTION

This is the opportunity you've been looking for—a chance to create a really effective businesspaper advertisement.

YOU CAN EARN $1000

To satisfy this long-time, deep-felt urge—and earn $1000 in the bargain—send us copy and a rough layout for *one* advertisement (any size, color or not, as you see fit). This ad should be capable of attracting the interested attention of industrial advertisers with a stake in the automation market. It should point up the values AUTOMATION magazine holds as a medium for reaching buyers of automatic production equipment.

MORE THAN ONE WINNER

This is not a one-winner contest. AUTOMATION will pay $1000 to the creator of each advertisement it decides subsequently to use as part of its advertising campaign. AUTOMATION editors will be the judges. Contestant's identity will remain anonymous during the judging.

FOR HELPFUL BACKGROUND INFORMATION

Pertinent information about AUTOMATION's market, readers and objectives for use in preparing your entry appears on the back of this page. If you desire additional material, please write and we will send you a booklet supplying complete details.

DEADLINE IS NOVEMBER 30, 1959

The competition is open to all. Anyone with a creative flair is urged to try his skill. Yours may be just the idea we're looking for. Send completed entries to $1000 Reward, c/o AUTOMATION, Penton Building, Cleveland 13, Ohio.

Background Information to Help You Win

$1000 REWARD

(For complete contest details, please see reverse side)

The Marketing Man's Stake in Automation

Automation is the marketing man's challenge today—and in the future. His ideas *must* match this manufacturing concept. The creative marketer realizes that as an absolute first condition, automation requires the establishment of a predictable, stable, and expanding market. Economic and sociological pressures force automation on us; automation forces new marke.ing concepts on us.

The building of a constant market will require a more complete circuit of communication. Now, the manufacturer-customer flow of information largely goes from the maker to the buyer. But with automation, we will have to know more about what the customer wants. Needed are improved ways to get better communication from maker to user and then back again.

The Management Man's Stake

Automation, or continuous automatic production, naturally will grow out of more complete mechanization. We have progressed from the manual area through the mechanization area and are now well into automation. Any discussion about whether automation is desirable is a futile intellectual exercise. We might as well argue whether the tides and the seasons are desirable.

The dawn of mechanization at the turn of the century brought a new era of lower costs and a higher standard of living than would have been possible in a manually operated economy. Now, we are approaching the upper limits of cost and labor reduction possibilities in a mechanically operated economy. We need a new breakthrough—and it will come through automation.

In the words of D. S. Harder, former Executive Vice President, Basic Manufacturing Divisions, Ford Motor Co.

"Time has proved that the machine age is a boon—not a bugaboo . . . Manufacturers, large and small, have to make a choice. They can heed the warnings of uninformed doom prophets and retard our industrial progress—a road leading to oblivion. Or we can all have faith in ourselves and our ability to harness the potential of this new phase of industrialization for the benefit of all."

The Manufacturing Engineering Function

When industry first backed into automation without precision engineering, it had plenty of trouble. As a result, the manufacturing engineering function developed and has become industry's fastest growing and most important buying influence for automated production equipment.

Industry is changing from a departmentalized approach to a three-phase approach.

PHASE ONE—the processing or work-performing phase, which includes all the steps that alter or combine materials.

Phase Two—the handling phase, which encompasses the movement of materials in process within or between machines.

Phase Three—the control phase, covering the automatic cycling of functions 1 and 2—either independently or integrated.

How AUTOMATION Serves This Function

Edited for men with *manufacturing engineering* interests and responsibilities . . . AUTOMATION serves all industries. It reports and interprets all significant advancements and trends relating to automation, including planning, development, design, installation and maintenance. It provides for the exchange of ideas from one industry to another. This cross fertilization is the time-and-money saving link between those who have solved a production process problem and those who are still looking for a solution.

Why Users Read AUTOMATION

AUTOMATION is directed particularly to manufacturing engineering and operating management men in industry who are responsible for, or directly interested in, automation. Editorial and advertising pages provide the basis for their decisions concerning the adoption or improvement of automated equipment and manufacturing systems for their own use.

Why Designers and Builders Read It

In addition, AUTOMATION appeals to engineers and management men in companies that serve the special automation needs of industry . . . the manufacturing engineering function to industry. It gives designers and builders specific job help relating to all types of automated original production equipment . . . from single automatic machines to fully integrated lines and plants.

Reaches a $5 Billion Market

A continuing industry-wide study pinpoints the tremendous potential for Production Equipment, Handling Equipment, Power Drives and Automatic Control Equipment in this vast market controlled by the manufacturing engineering function. This "Survey Report and Automation Forecast" provides you with a new measure of marketing trends. Ask your AUTOMATION Representative to show you how to incorporate its data into *your* marketing plans.

Attracts a 90,000 Buyer Audience

AUTOMATION's vital readership is concentrated among 90,000 key buying influences . . . the manufacturing engineering and management men who specify, recommend, approve and buy your products. It reaches the important influences of the buying team . . . the men your salesmen don't always get a chance to contact and, yet, would *prefer* to contact.

High Response to Editorial

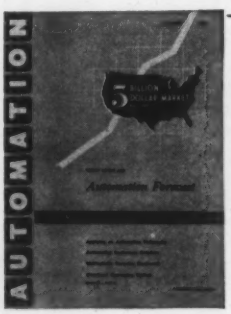
Written by manufacturing engineers for manufacturing engineers . . . AUTOMATION is geared to the exact needs and wants of its readers. Its editorial pages clearly communicate—create respect and response! This high level of reader interest is documented by reprint requests (averaging over 130,000 annually) and continually high Starch readership scores.

High Response to Advertising

Every advertisement in AUTOMATION is directed to the manufacturing engineering function, production-management men, or the designers of production equipment. No waste circulation . . . for every reader has the *need* to know about these products and the *power* to buy them.

Market Planning Help

You get more effective results from your advertising and help in reaching key automation-minded men in industry, too, with a complete marketing plan which includes: The Penton Census . . . the Continuing Industry-Wide Study of Automation . . . Reader Action Reports . . . Market Data Sheets . . . Starch Scores . . . plus many other Merchandising Aids. Your AUTOMATION Representative is prepared to help you make the most of industry's fastest growing and most influential function—*manufacturing engineering.*



Get ACTION from the men who buy and specify . . .

- *Production Equipment*
- *Handling Equipment*
- *Power Drives and Automatic Control Equipment*

AUTOMATION

A Penton Publication
Penton Bldg., Cleveland 13, Ohio

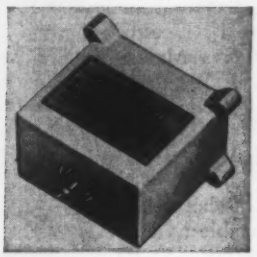
in. chrome-plated arms of parallel mechanism plus off-corner mounting combine to provide easy coverage of entire board surface with both vertical and horizontal scales. Protractor is detachable and reads 90 deg each side of zero. Both 9-in. scales are graduated in inches, 32 divisions to the inch, and are reversible for full or half-scale drawing. **Drafting Equipment Co.**, 504 Randolph St., Meadville, Pa. F

Circle 751 on Page 19

DC Accelerometer

for high-performance applications

Small-size, lightweight Model 24124 dc accelerometer with potentiometric out-out has low natural frequency with relative high resolution. It is available in wide flexibility of standard ranges from ±5 to 50 g and natural frequencies



from 15 to 48 cps. Unit withstands 11 millisec shock and 50 g steady-state acceleration in any axis without structural damage. Fluid damping is provided at low temperature to minimize shock and vibration. Operating temperature range is −54 to +71 C with accuracy band of ±5 per cent for over-all environmental conditions, including linearity and hysteresis. **Giannini Controls Corp.**, 918 E. Green St., Pasadena, Calif. L

Circle 752 on Page 19

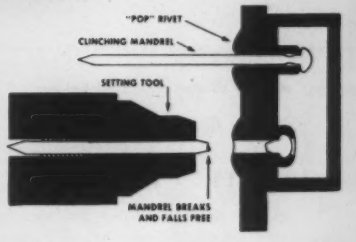
Potentiometer Pickup

resists 100 g shock and static acceleration

No. 4-380A potentiometer pressure pickup is available in differential, gage, and absolute models with ratings from 0-10 to 0-100 psi. Characteristics of linearity, resolu-

"POP" RIVETS

Assemble finely finished wood chair panels, enameled or painted metal sheets, "POP" Rivets save the surface. Setting tools can't slip. Burrs on fastener head and countersinking are eliminated.



HOW THEY WORK — "POP" Rivets are assembled on a precision high-tensile mandrel. Mandrel head is drawn into the reverse side of rivet with a setting tool. Mandrel head breaks off under tension clinching the rivet. Work is squeezed by compression — controlled radial expansion. Setting tools from $18 to $300.

"POP" Rivets set by compression without the turning action which tears the surface finish allowing corrosion to start. Fasten sheets as thin as .020 dead soft aluminum or 24 gauge steel without distortion. Use thinner materials without creating a fastener problem.

"POP" Rivets install and set from same side. Get this design advantage for your product. Set up to 1,000 an hour with unskilled help. 50% savings in installed fastener costs suggest your immediate investigation.

"POP" RIVET DIVISION
UNITED SHOE MACHINERY CORPORATION
RIVER ROAD, SHELTON, CONN.
REgent 5-3391
US 9-40

UNITED "POP" RIVETS

Circle 582 on Page 19

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Limited supplies of the following reprints of articles which have appeared in MACHINE DESIGN are still available at no cost. Circle the ones you want on the order form below and mail to Reader Service, MACHINE DESIGN, Penton Building, Cleveland 13, Ohio.

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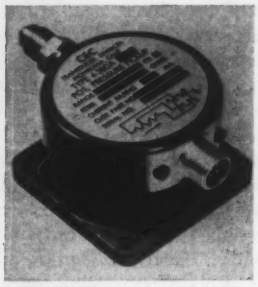
ENGINEERING DEPT. EQUIPMENT



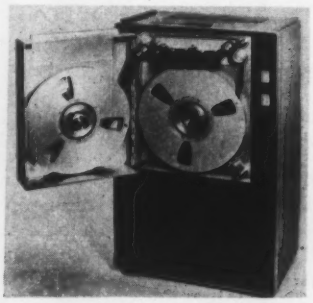
tion, hysteresis, repeatability, friction effect, thermal response, dielectric, and environmental operation meet or exceed specifications of military and all manufacturers. Potentiometer wattage rating is ½ w and coil life is 1 million cycles. Unit withstands 100 g shock and static acceleration on three orthogonal axes without damage or unusual response. It operates in vibration environments to 25 g for many hours, and throughout frequency band to 3 kc. Operable temperature range is −65 to 200 F, and maximum temperature is 300 F. **Consolidated Electrodynamics Corp.**, 360 Sierra Madre Villa, Pasadena, Calif. L

Circle 753 on Page 19

Instrumentation Recorder

is 14-channel, portable unit

PS-214 recorder - reproducer, designed to replace large, rack-mounted installations, provides laboratory precision in a portable cabinet. Completely transistorized, unit features modular construction and printed-circuit boards to allow interchange of any number of direct or FM channels up to 14. Recorder is magazine-loading for rapid replacement of tape or substitution of a continuous loop magazine; only 5 sec are required to change maga-



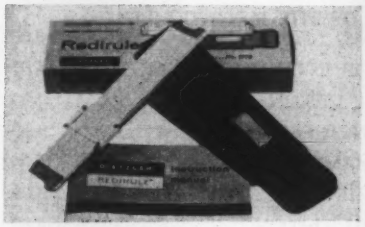
zines. Any number of the unit's available tracks can be used for high-frequency recording, low-frequency data, transient phenomena, and quasistatic measurements. Variety of data can be recorded concurrently with common time base. Six speeds are available by means of pushbutton selectors and belt changes. **Precision Instrument Co.**, 1011 Commercial St., San Carlos, Calif. M

Circle 754 on Page 19

Slide Rule

is 9-in. pocket type

Redirule 1776 is a 9-in. pocket slide rule with genuine leather case and stainless-steel clip. Made of nonwarping acrylic plastic, it contains 15 deep-etched scales to solve al-



most any conceivable problem. Complete instruction manual is provided. **Eugene Dietzgen Co.**, 2425 N. Sheffield Ave., Chicago 14, Ill. J

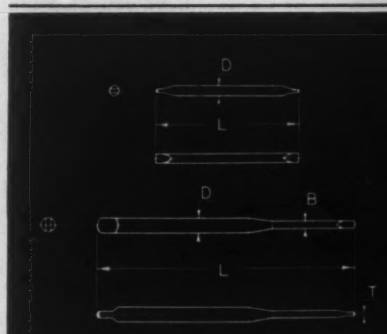
Circle 755 on Page 19

Copying Machine

fast-operating unit is fully automatic

Xerox 914 copier is a pushbutton unit which requires no sensitized or treated papers, nor does it require any exposure or developing adjustments. Required number of copies can be made by simply setting a dial. There is no need to handle copy paper or rehandle original for multiple copies. Unit operates on fast, dry, electrostatic principles of xerography. It copies all colors, and rapidly prints finished, permanent copies or any written, drawn, typed, or printed document up to 9 x 14 in. in size. Machine also permits copying from bound books or magazines as easily as from individual documents. Prints can be made directly on ordinary white or

NEWS
from Torrington on
SMALL PRECISION METAL PARTS



DOUBLE END BLADES

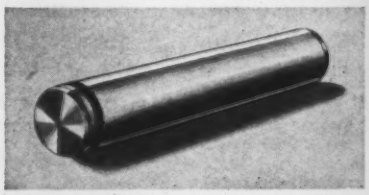
D = .024" to .060
L = 5/8" to 2

JEWELERS' BLADES

D = .098" to 1875
B = .025" to .100
L = 1-9/16" to 3
T = .004" to .015

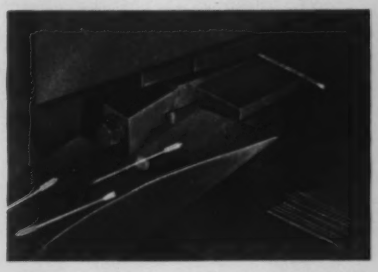
"Custom manufacture" has a special meaning at Torrington, where our Specialties Division produces a tremendous variety of small precision metal parts. For our engineers often help in designing parts for our customers, and as frequently develop special equipment or methods for most efficient production.

For example, one of our current contracts is for jewelers' screwdriver blades. In this case, our engineers decided to swage these parts to give the required high-strength characteristics without stress concentration points and tool marks. Other features of these parts are good dimensional accuracy and closely controlled heat treating for hardness and temper.



In another case, we received a blueprint of a special pinion axle with an accurately cut retaining ring groove at one end. The customer inquired whether this part could be produced at about the same price as a straight cylindrical axle with an uninterrupted OD. The answer was "Yes!" Specialties engineers decided that high-speed cutoff and groove-turning equipment would have to be built to cope with the high volume involved. Special pinion axles have now joined the great number of parts being produced by Torrington Specialties Division.

Whatever the part, whatever the operation—even operations tailored to the part requirements—Torrington's Specialties Division is uniquely equipped to handle your small precision parts contracts. Highly specialized fluting opera-



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Circle 584 on Page 19

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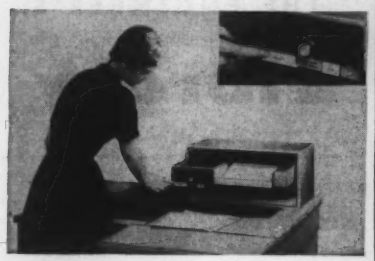

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Circle 756 on Page 19

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driven slide wire to balance an internal bridge circuit. It is available in 13 models expected to meet the majority of application requirements. Specified accuracy is ±0.15 per cent of full scale. Electronics & Instrumentation Div., Baldwin-Lima-Hamilton Corp., 42 Fourth Ave., Waltham 54, Mass. B

Circle 757 on Page 19

GRC DIE CASTING METHODS CUT TINY BUSHING COSTS TO $2/M

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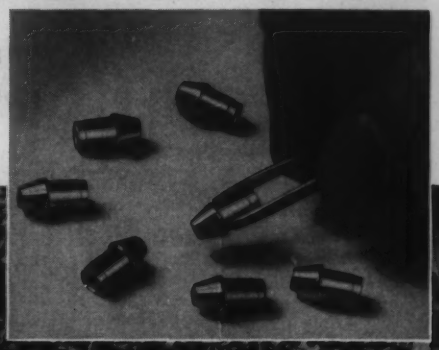

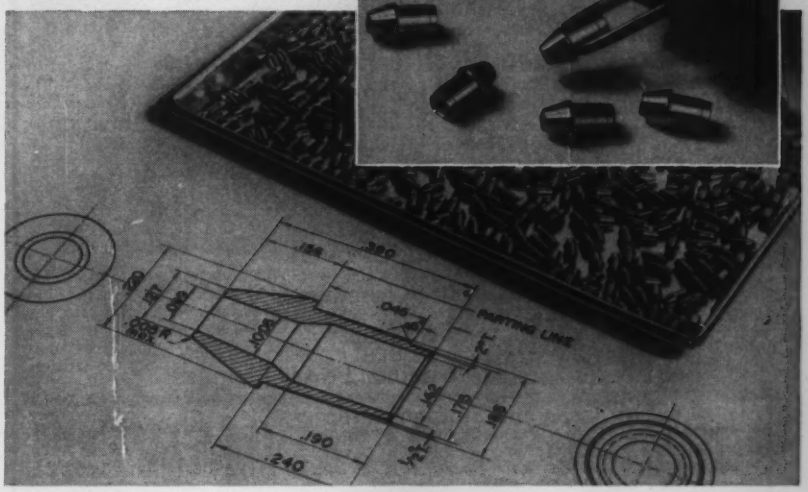

This tiny bushing is used in a ball point pen. Overall it is .390" long and .220" wide. It was formerly made on screw machines, but Gries Reproducer Corporation was able to die cast it in zinc alloy in a single automatic operation reducing the cost to little more than $2.00 per thousand. In addition to lowering cost substantially, GRC exclusive methods guaranteed the perfect uniformity of each individual piece in the million part run. The manufacturer also took advantage of GRC's service to their customers on secondary operations and had the part nickel plated.

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Machinery's Handbook. *By Erik Oberg and F. D. Jones, edited by Holbrook L. Horton; 2104 pages, 4½ by 7 in., clothbound; published by The Industrial Press, 93 Worth St., New York 13, N. Y.; available from* MACHINE DESIGN, *$11.00 per copy postpaid.*

Growth and data accumulation in mechanical industries, new American and British standards, and advances in materials and alloys are reflected in this 16th edition. Complete revision of the screw-thread section includes changes in standards, a new thread series, tapped-hole sizes, and designations for ground-thread taps.

Formulas and tables for beams, plates, cylinders, tubes, and shells have been added. A complete section on design and selection of plain bearings is provided, and information on wood, plastic, and rubber bearings is given. Descriptive and dimensional data cover all types of ball, roller, and needle bearings.

New tables and data are presented for gears, worm drives, and ratchet arrangements. Information on involute splines and serrations occupies another new section. Also new are detailed descriptions of the most used spring materials.

Source Book of the New Plastics. *By Herbert R. Simonds; 354 pages, 6 by 9 in., clothbound; published by Reinhold Publishing Corp., 430 Park Ave., New York 22, N. Y.; available from* MACHINE DESIGN, *$10.00 per copy postpaid.*

Information about new developments in the broad plastics industry is provided in this reference book. Descriptions of many new materials have been furnished by actual producers. Properties, production, price, applications, and selection of seven new primary plastics and many secondary materials developed within the last two years are presented. Recent and significant improvements in established plastics are also report-

ed. A survey of federal-sponsored plastics research and a list of selected 1958 plastics patents are included.

Association Publications

Tabulation of Unions Representing Engineering and Technical Employees. *9 pages, 8½ by 11 in., paperbound, side-stapled; available from National Society of Professional Engineers, 2029 K St. N.W., Washington 6, D. C.; $1.00 per copy.*

Complete or authentic data on numbers and kinds of employees represented by, or members of, collective bargaining organizations have previously been unavailable. Another difficulty was lack of definitions and distinction between engineers, technicians, and production workers. In this tabulation are given employer, union name, number of employees represented, actual union members, a distinction between professional and nonprofessional employees represented, and source of information.

Government Publications

OTS Technical Reports. Copies of reports listed below are available from Office of Technical Services, U. S. Dept. of Commerce, Washington 25, D. C.

PB 151062. Tensile Properties of Titanium Alloys at Low Temperatures. By F. C. Holden, F. R. Schwartzberg, and H. R. Ogden, all of Battelle Memorial Institute; 43 pages, 8½ by 11 in., paperbound; $1.25 per copy.

Extensive studies of titanium and its alloys at −320 and −423 F are summarized. Only commercially produced alloys are covered; alloy source, composition, form, and heat treatment are included. Data are reported for notched and unnotched samples to show effects of variation in composition and microstructure.

PB 151720. Investigation of Design Criteria for Cushioning Materials. By Stewart M. Krakover and Albert Olevitch, WADC; 28 pages, 8 by 10½ in., paperbound, side-stapled; $1.00 per copy.

Theory of cushioning design, criteria for designing cushioning systems, examples illustrating application of design criteria, and a formula relating cost to significant material properties are discussed. Acceleration-static stress curves, creep values, and other design data are presented for several commonly available materials.

PB 151740. Thermal Buckling of Circular Cylindrical and Conical Thin-Walled Shells. By David Abir, N. J. Hoff, S. V. Nardo, Frederick V. Pohle, William Vafakos, and Koon-Sang Wan, all of Polytechnic Institute of Brooklyn; 169 pages, 8¼ by 10¾ in., paperbound; $3.00 per copy.

Theoretical and experimental investigations were conducted in the field of linear elastic theory. A 20-kw induction heating generator simulated aerodynamic heating on the specimens. Temperature and thermal-stress distribution, buckling-stress criterion, and experimental results were investigated for circular cylindrical and truncated circular conical shells. Specimens were both unreinforced and reinforced with axially symmetric longitudinal stringers and were freely supported with no external loading.

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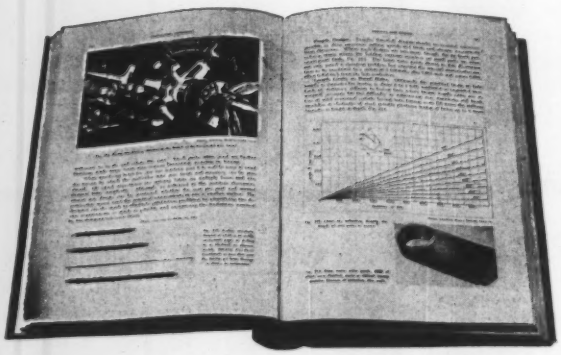

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Professional Viewpoints

. . . oil mileage . . .

To the Editor:

It is desired to comment on an item, "Oil mileage in '60 cars—more or less," which appeared in the August 20, 1959 issue, Page 23.

Regarding the lubricating oils in automotive engines and the frequency with which oil changes should be made, this is a subject that requires analysis, and change recommendations should be made based upon conditions and not just a flat across-the-board recommendation. We in refrigeration face similar problems regarding lubricating oils. Our problem differs only in degree, but the wide variation exists in our industry as well as in the automotive industry.

Regarding the automotive oil change, I speak from experience of having driven over 500,000 miles with my own personal cars. Oil does not wear out. It becomes contaminated depending upon the conditions of driving. In the winter when my car is driven only short distances, I find it advisable to change at least every 1000 miles. In the summer, and particularly on long trips, if speeds are held within good bounds such that the oil temperature does not reach excessively high values, I often run 5000 miles or more between changes.

In refrigerant compressors where outside contamination is completely eliminated and where compression ratios are held within reason, such as air conditioning applications with compression ratios not in excess of 5 to 1, a change of lubricating oil is not recommended. I have in my possession a connecting rod from a compressor which operated under these conditions in excess of 39,500 hours without service and without oil change. This compressor application was of the latest design high-speed equipment. If this compressor had been an automotive engine, operating at the same number of revolutions per minute, it would have traveled in excess of 1,750,000 miles.

When the refrigerating application is such that the compression ratio exceeds 10 to 1, oil contamination can be expected from actual oil breakdown due to the higher temperatures involved. Here the refrigerating industry is facing a similar problem (except in reverse) to that faced by the automotive industry. Because oil changing is not required in air-conditioning applications, it is next to impossible to convince customers using low-temperature refrigerating applications that periodic oil changes are advisable. In this case, these machines are permitted to operate until failure, because the time interval is sufficiently great that the problem is not alarming.

The important point I wish to make is that oil change recommendations should be tailored to the conditions of operation. I believe the public can understand this problem if it is explained properly.

—E. T. Neubauer
Vice President in Charge of Engineering
Copeland Refrigeration Corp.
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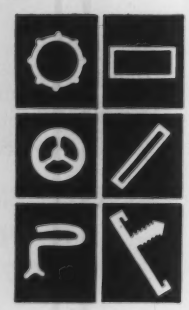

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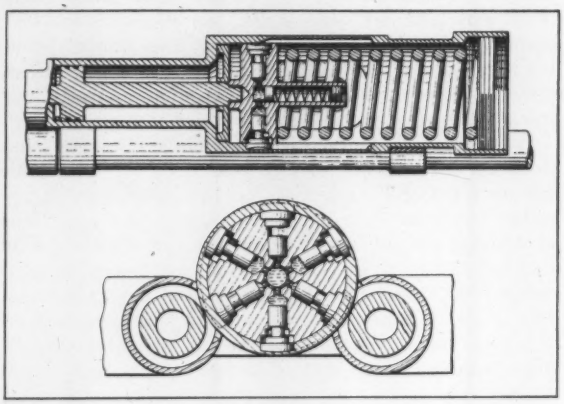
NOTEWORTHY

Patents

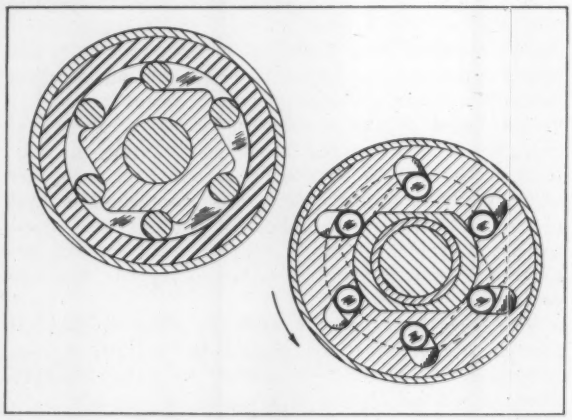
Cam-Guided Piston

A piston which is forced to reciprocate axially is also forced to rotate, simultaneously, through a definite arc



of less than one turn per work cycle. Rotation is guided by six rollers in radial bores in the piston. At all times, half the rollers engage grooves which have U-shaped paths in the ID of the cylinder. To insure co-ordinate radial motion of all rollers, the roller bores are connected by a closed circuit of channels filled with an incompressible fluid. *Patent 2,902,869 assigned to the United States of America (Army) by Eugene S. Wassel and Mitchell J. Shoelson.*

Overload Slip Coupling

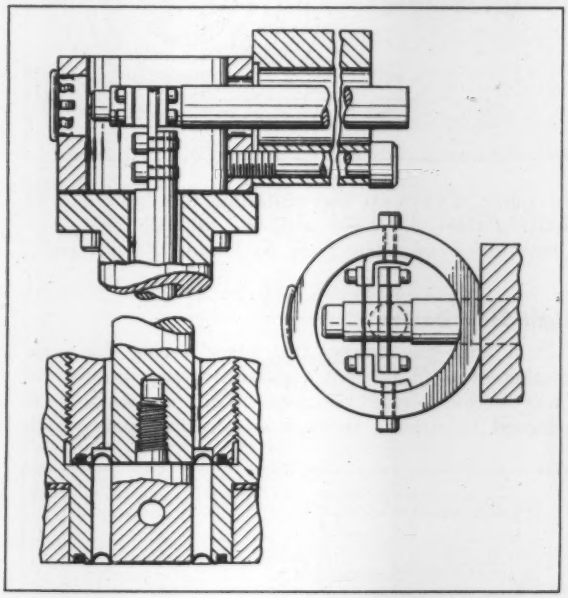


In a shaft coupling designed to provide overload protection, a number of pins, parallel to a drive axis, are carried between a symmetrical cam and a resilient ring

which is surrounded, in turn, by a rigid sleeve. The same pins project into slots in a driven plate. Overload causes the drive cam to force the pins outwardly into the resilient ring far enough to pass the high points of the cam. The slots in the driven plate are elongated to accommodate this pin motion. *Patent 2,902,864 assigned to Bendix Aviation Corp., Elmira Heights, N. Y., by James J. Digby.*

High-Temperature Pressure-Sensing Device

A pressure sensing device responds to pressures as high as 2500 psi in process materials as hot as 300 C. To assure accurate readings, the sensing head is in direct



contact with the process material and the complete device is entirely mechanical. A diaphragm on the sensing head is made of stainless steel 0.001 to 0.005 in. thick. Pressure of the process material moves the sensing head axially in the range of 0.0001 to 0.0002 in. This motion is transmitted, by a central shaft, to the center spring in a pivot assembly. The off-center spring in this assembly is a stationary pivot which serves to amplify the pressure readings. *Patent 2,902,861 assigned to the Swartwout Co., Cleveland, by Richard H. Frost and Earl O. Schweitzer.*

Antibacklash Gear Assembly

To eliminate backlash between meshing gears, one gear is split parallel to its end faces into two parts which are functionally identical. The two parts are connected by an annular round-wire spring which causes the gear halves to bear in opposite directions to take up backlash. An error in this arrangement is that one of the gear halves is a datum with respect to the other. To divide compensating motion equally, separate links are pinned to each gear and joined to a

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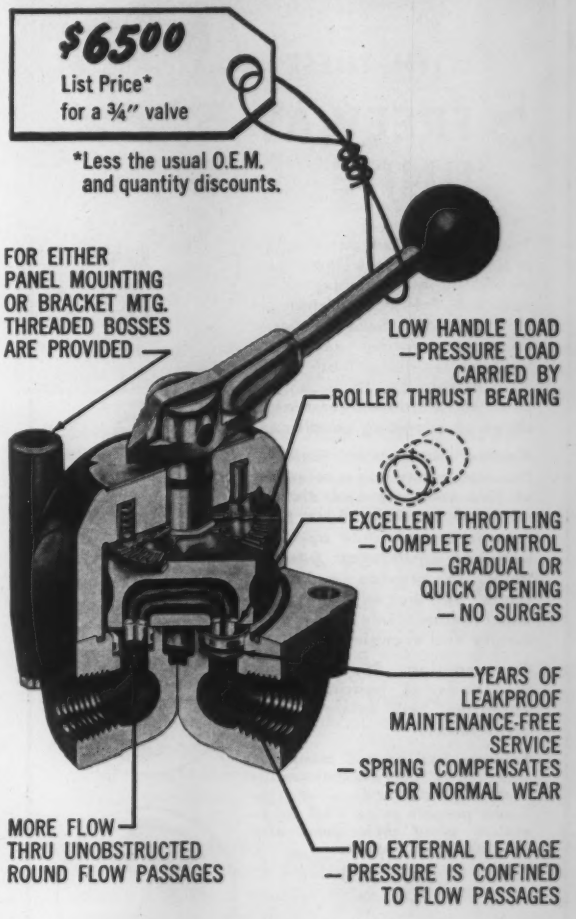
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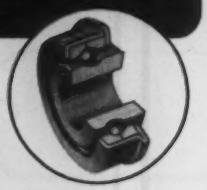

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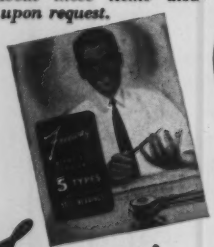

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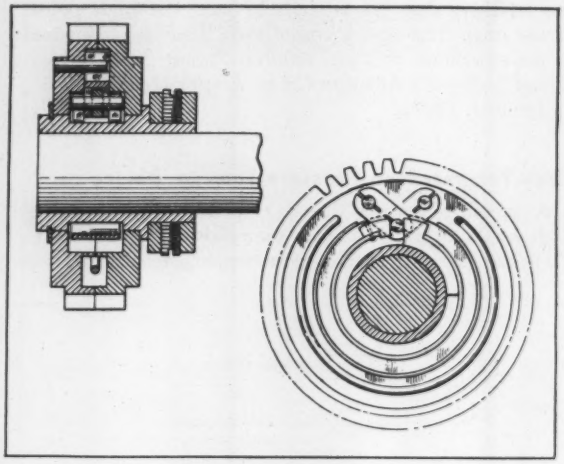
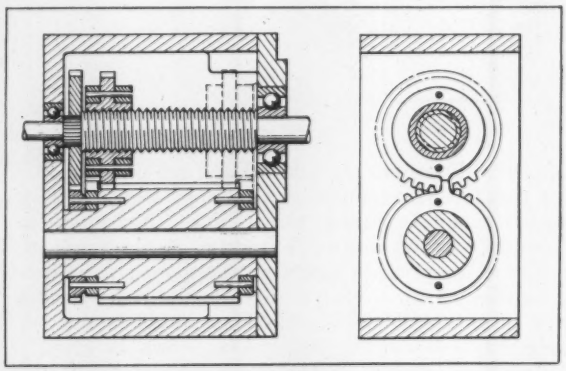
third "floating" pin. A flat bow spring holds the third pin against a flat surface so that linear movement of



the pin is always on one centerline through the gear shaft. *Patent* 2,902,879 *assigned to Bell Telephone Laboratories Inc., New York, by Johan R. Andersen.*

Limit-Stop Device

In a limit-stop device, two gears having the same number of teeth achieve a relatively large number of turns between stop positions. This performance is achieved by driving through an auxiliary pair which

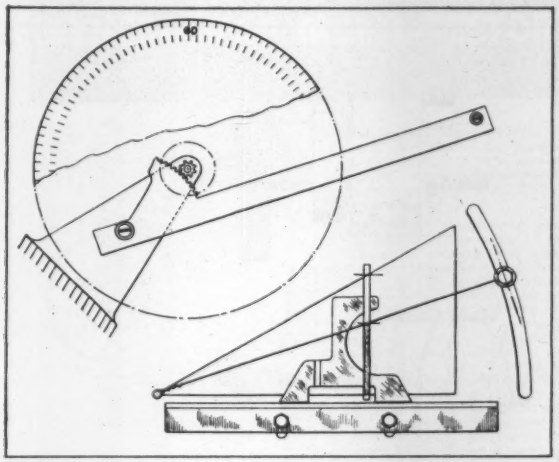


differ by one tooth. One gear, fixed on the input shaft, drives the added pair. Another gear, having the same number of teeth as the driving gear, travels an input leadscrew. *Patent* 2,902,876 *assigned to Librascope Inc., Glendale, Calif., by William E. Pollock.*

Proportion Measuring Device

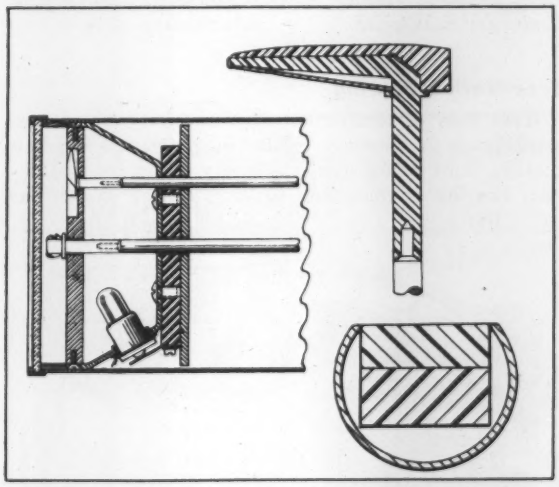
Direct percentage readings of one linear distance with respect to a larger distance are obtained quickly on a mechanical indicating device. A subject, such as a test tube less than full, is mounted on an adjustable carriage. After zero and full levels of the subject are aligned with corresponding lines on the instrument, a

wire is positioned to pass through the unknown level. Identical movement of a beam rotates a calibrated dial



which displays the percentage reading through a window. *Patent* 2,900,730 *assigned to Clay-Adams Inc., New York, by Marvin A. Gilman.*

Internally Illuminated Dial Pointers



For instrument display, dial pointers are illuminated from within themselves to a level of brightness clearly visible by day and adequately visible at night. Light from a bulb behind the dial is transmitted through plastic pointer stems, into the pointers themselves. This path is assured by the angles of two polished reflecting surfaces at opposite ends of plastic stem lengths. The outer surface of the pointers is opaque white glass. *Patent* 2,902,970 *assigned to Avien Inc., Woodside, N. Y., by Ladislav Kadlec.*

Torque-Limiting Clutch

By adjusting the position of one end of a columnar spring, a torque limit can be set at which principal members of a clutch disengage. Disengagement occurs

share a mold—
divide the cost
AT ATLANTIC CASTING

Typical Atlantic Production Mold-Half (18" x 12")

PRODUCTION COSTS FOR PRECISION CASTINGS SHOWN ABOVE WERE SHARED BY THE FOLLOWING COMPANIES:

General Electric Company; Intertype Corporation; Westinghouse Electric Corporation; Air Reduction Corporation; United Shoe Machinery Corporation; I.T.E. Circuit Breaker Company; Ordnance Corps. Dept. of Army; Vonnegut Hardware Company.

PRECISION CASTINGS COST LESS AT ATLANTIC because production molds are shared by up to fifteen different customers and fifty castings. Standard production molds are produced and poured on a continuous basis and when an order for a casting is completed, the portion of the mold vacated is immediately utilized for another casting, while production proceeds without interruption.

TOOLING COSTS CUT!
Atlantic mold-sharing requires only one inexpensive, brass pattern, quickly produced and easily altered.

LABOR COSTS CUT!
Pouring as many as fifty castings in a single mold allows substantial reduction in labor costs per casting. This saving is passed on to you.

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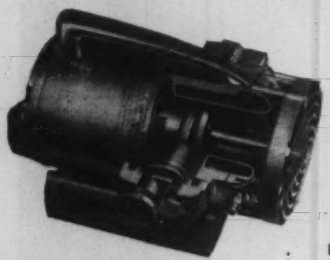
Circle 592 on Page 19

Oil-Free COMPRESSED AIR FROM YOUR CHOICE OF 58 MODELS

Completely oil-free air—no lubrication ever needed when you choose one of these 58 B&G Oil-less Compressors. Carbon graphite piston rings and skirts need no lubrication—motor bearings are *permanently* lubricated. Numerous other design and construction features assure long life and smooth dependable delivery of cleaner, cooler, drier air.

For portable or built-in applications, these lightweight, compact compressors give maximum air per horsepower.

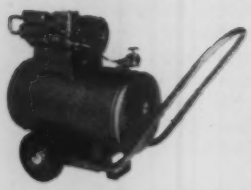


Oil-less Motor Compressor Units—35, 75 and 175 lb., single and two-stage, ¼ to ¾ H.P.

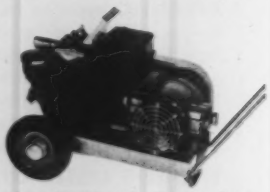
Bare Compressor (less Motor)—35, 75 and 175 lb. pressures, for belt-driven applications.

Tankless Motor-Compressor Outfits—for use where existing air tanks or pipe lines provide air storage. 35, 75, 175 lbs., single and two stage. ¼ to ¾ H.P.

"Piggy-Back" Compressor Tank—Handy 2-gallon tank mounts on any B&G 75 or 175 lb. Motor Compressor or Tankless Outfit.



10-Gallon Air Tank Motor-Compressor Outfits. 35—175 lbs.—mounted on Code or non-Code Tanks. Portable when cart-mounted.



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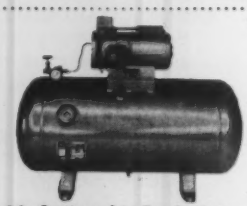

30-Gallon Air Tank Motor-Compressor Outfits—75 and 175 lb. units. Vertical or horizontal ASME Code tanks tested to 400 lbs. ¼ to 1½ H.P.

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BELL & GOSSETT COMPANY

Dept. FX-67, Morton Grove, Ill.

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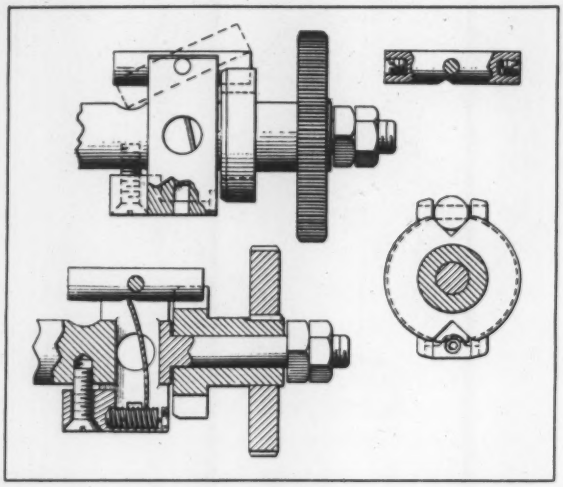
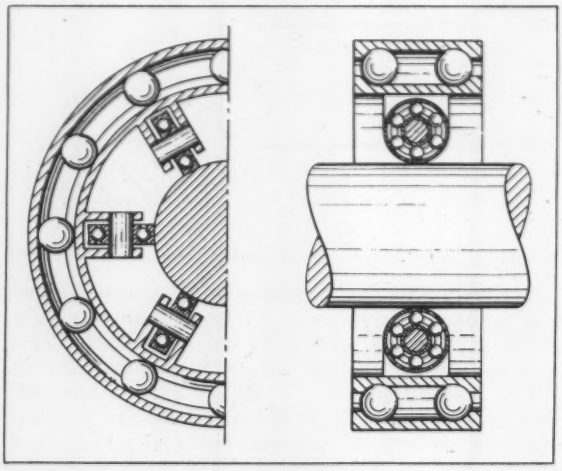
when excessive load cams a connecting pin out of a detent in the driven member. After disengagement, centrifugal force tends to hold the connecting pin in the



disengaged position. Because there is no other connecting member, the clutch will run disengaged without wear or heating. *Patent* 2,903,112 *assigned to General Electric Co. by Harold S. Foster, Robert E. Bosch, and Chauncey E. Warner.*

Free-Motion Bearing

Two sizes of antifriction bearings comprise an assembly which presents minimum resistance to shaft motion, both rotary and translatory. An outer antifriction bearing enables free rotation of the shaft. The



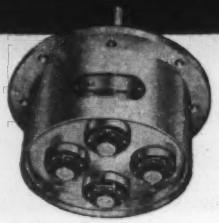
inner race of this larger bearing carries a number of smaller antifriction bearings which contact the shaft and have axes in planes perpendicular to the shaft axis. The cluster of small bearings enables free shaft translation. The assembly is intended for use where fine tolerances must be observed. *Patent* 2,903,307 *assigned to the United States of America (Navy) by Roger W. Peters.*

One Device Detects & Controls

MULTIPLE SPEEDS

• ACCURATELY • POSITIVELY • RELIABLY

SYNCROSNAP MULTI-TECTOR



covered by patents and patents pending.

Syncro-Snap MULTI-TECTOR detects and controls as many as eight separate circuits, and actuation can be accomplished on a high and low speed limit on each circuit.

For instance, inter-related speeds on automated systems can be synchronized. Machine tool speeds can be controlled as accurately as ¼ of 1%. Speeds of various components in aircraft and missiles can be sequenced or synchronized. Separate drives on equipment, such as large printing presses, can be actuated at predetermined speeds. A typical use is a four-stage MULTI-TECTOR on diesel engines which (1) cuts out cranking motor, (2) actuates cooling circuit, (3) controls fuel requirements, and (4) signals full speed and "too-low" speed.

MULTI-TECTOR measures only 5" in diameter x 4" deep. Housing is standard to provide maximum economy. Individual Syncro-Snap switches used in the MULTI-TECTOR operate on speed alone, regardless of voltage or load. They possess a life expectancy of 1.5 to 3 million cycles, with no signs of frictional wear and no variance in operating characteristics. Send requirements today for quotations.

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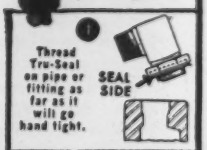
1
Thread Tru-Seal on pipe or fitting as far as it will go hand tight.
SEAL SIDE
2
Thread pipe or fitting 3 threads into port. Point in desired direction.
3
Tighten Tru-Seal to complete leakproof assembly (only light torque required).

Circle 595 on Page 19

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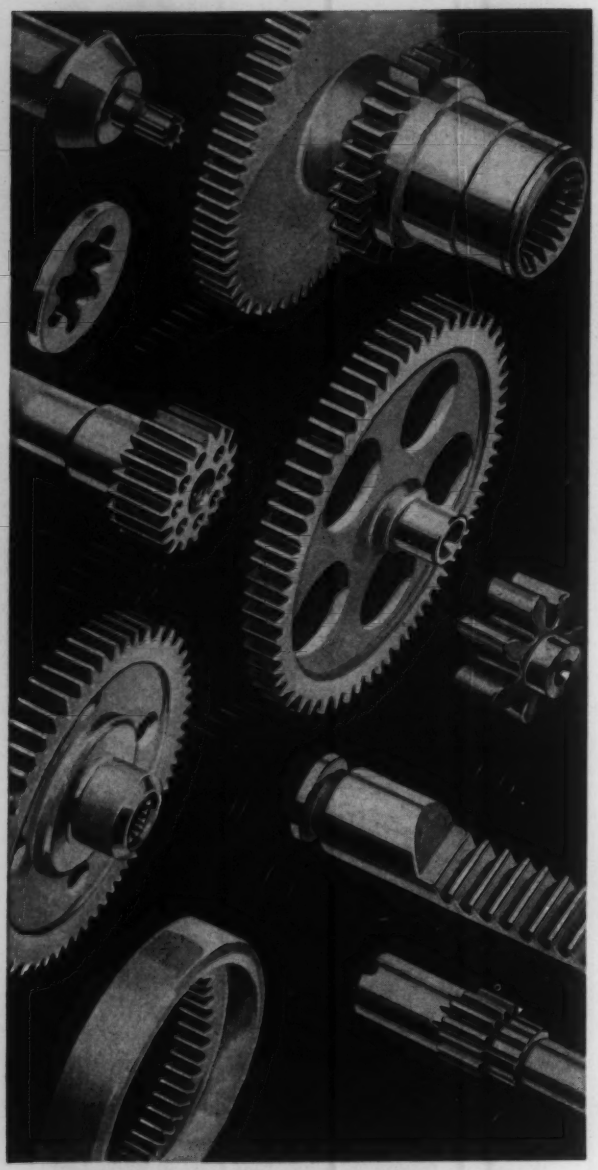
BCA BALL BEARINGS

BEARINGS COMPANY OF AMERICA

Circle 596 on Page 19



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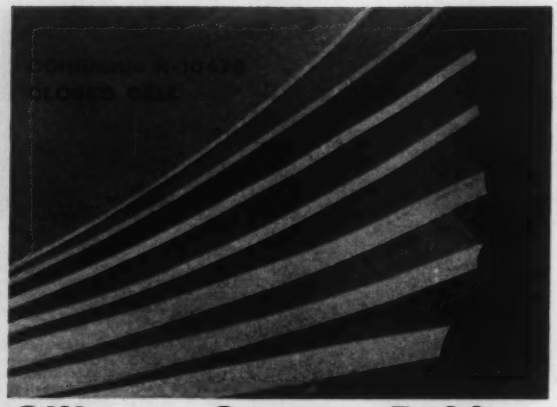

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BOWSER

FLOW indicating DEVICES

Tell when liquids are moving, if quality is right, and indicate flow.

Fig. 55A Flow Sight

Fig. 811 Flow Indicator

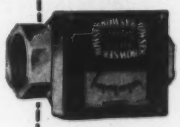

Fig. 816 Teleflow Indicator

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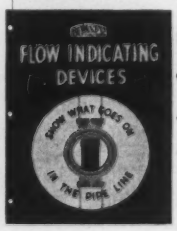

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MARKETING DIVISION

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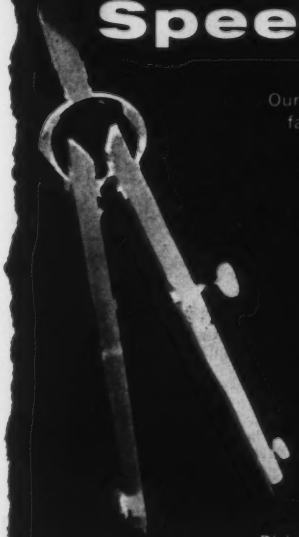

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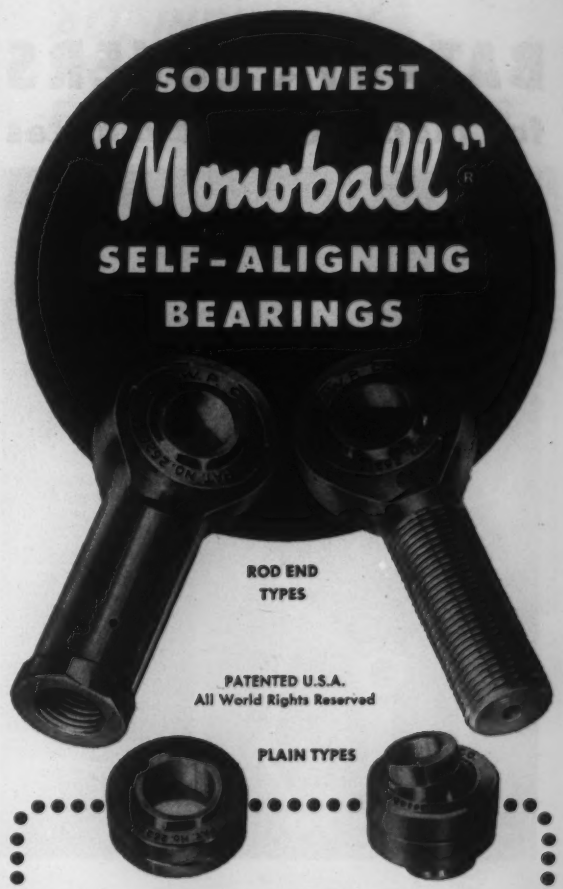

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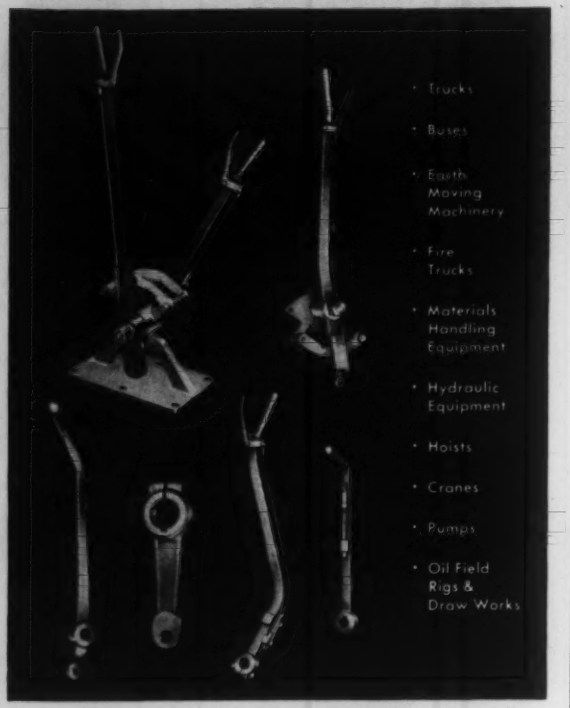
Circle 602 on Page 19

BATAVIA LEVERS

for machines and vehicles



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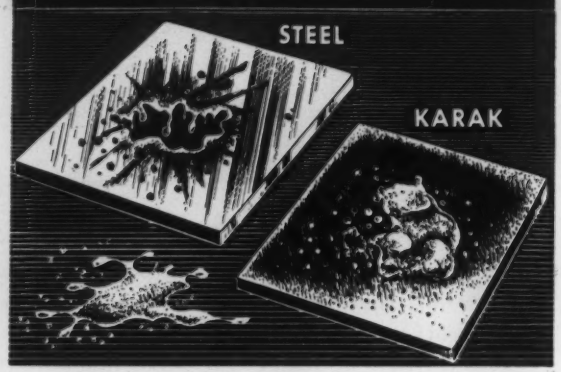

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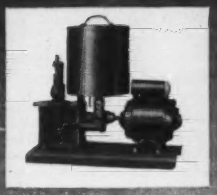
Circle 605 on Page 19

precision metering

MANZEL



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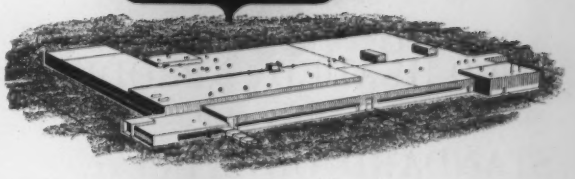

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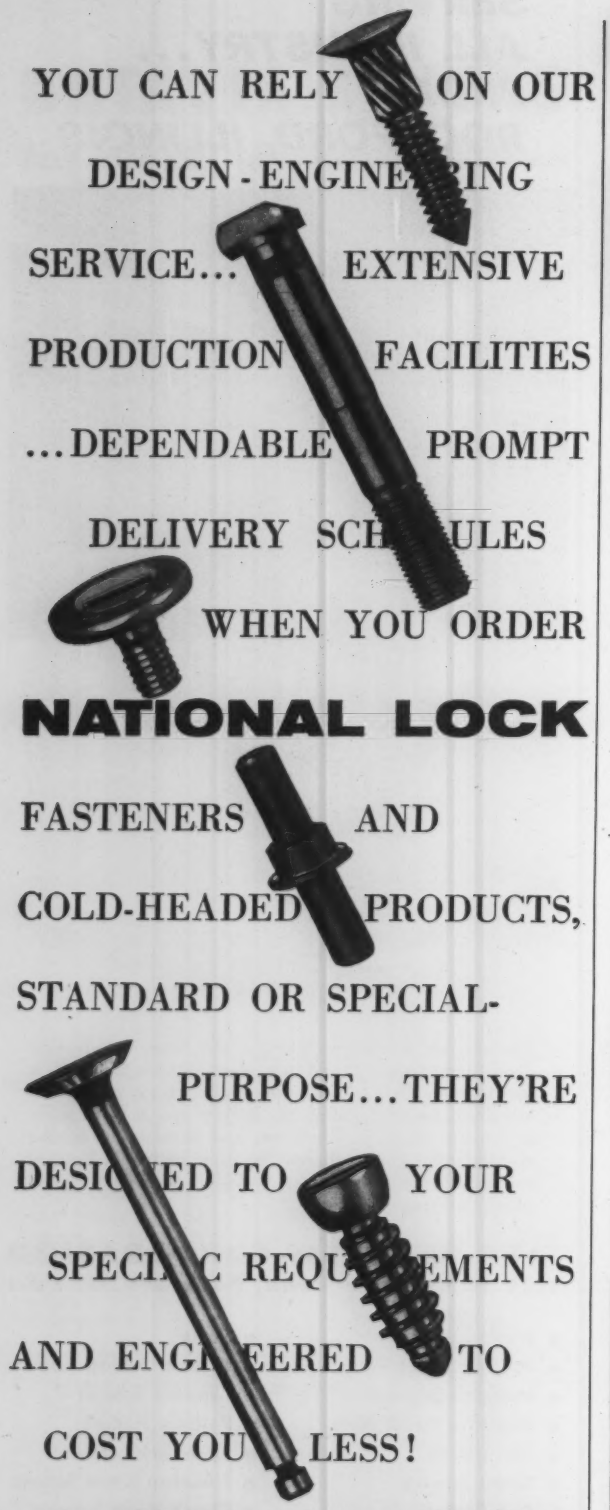

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Zinc and Aluminum
DIE-CASTINGS

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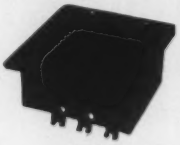

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Socket contacts of phosphor bronze, knife-switch type, cadmium plated. Plug contacts hard brass, cadmium plated. Made in 2, 4, 6, 8, 10 and 12 contacts. Plugs and sockets polarized. Long leakage path from terminal, and terminal to ground. Caps and brackets, steel parkerized *(rust proofed)*. Plug and socket blocks interchangeable in caps and brackets. Terminal connections most accessible. Cap insulated with canvas bakelite.

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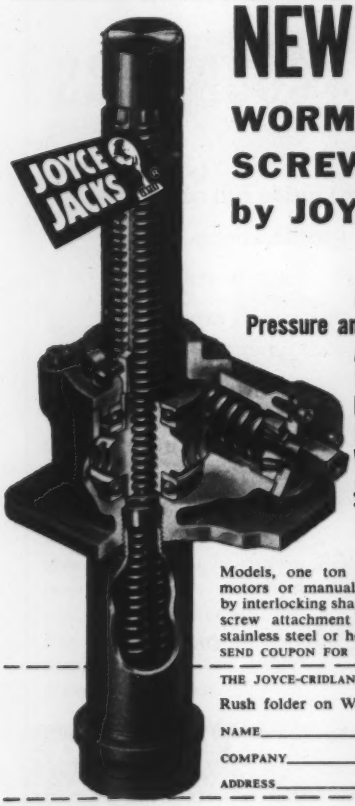

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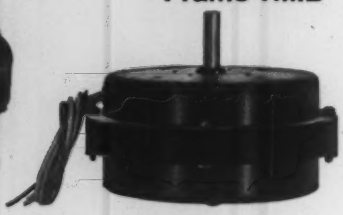
Frame HM



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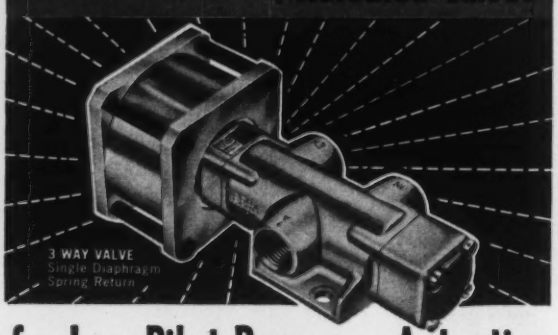

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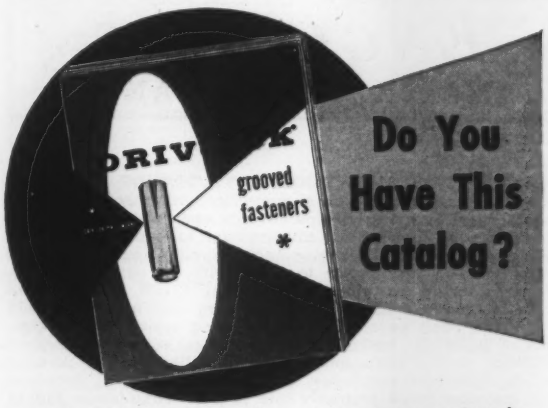

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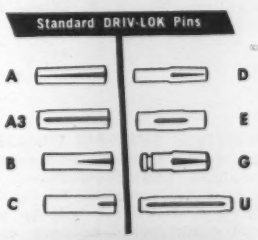

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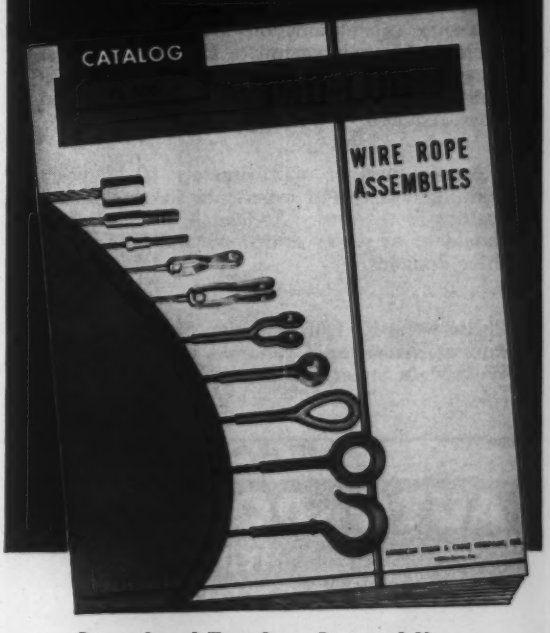

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Circle 621 on Page 19

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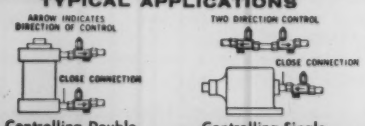

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Circle 622 on Page 19

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BPA NBP

backtalk——

——A Backward Glance

MACHINE DESIGN's thirtieth birthday, observed last month, tickled our nostalgia bone, which in turn caused the first preaxial digit of our forelimb to thumb through some early bound volumes. While this was not as hilarious as looking through an old family album, several items published 25 years ago seem interesting —indeed prophetic—enough to mention.

The "co-operative spirit that characterizes America and particularly its engineers" was manifesting itself in the form of assistance to the Soviet Union in furthering that backward nation's engineering progress.

Automotive designers were announcing development of a new system of "sealed cooling" which claimed to eliminate the necessity for constantly adding water to radiators.

This was the way we washed our clothes?

Another design "first" of 1934 was a washing machine styled to look like a kitchen cabinet. An ironer or a mixer could receive power from the wringer shaft, there was an outlet for other appliances, and the washer was wired for radio. Not only that, but future models were promised with the radio—thoroughly insulated of course—built right in!

Well, we have since noted the effectiveness of our aid to Russian engineers, and we are all happier motorists because of the assurance that our autos won't run out of water. But isn't it a pity that the musical washing machine never caught on?

——Author! Author!

Most of you, according to readership surveys, read our editorial page. You have, therefore, just received a gentle suggestion to get the lead out of your pencil and onto some paper in the form of an article that will enlighten other members of your profession. Following up Colin Carmichael's inspirational urging, we hereby offer assistance to anyone who may be hesitant about preparing material for publication. We have a pamphlet, *Meet Mr. MD,* which describes a typical reader and outlines subjects of interest to him. A companion piece, *That Article,* tells why and how to write for this journal. These author guides, both prepared by the editors, can be had for free by writing Editorial Dept., MACHINE DESIGN, Penton Bldg., Cleveland 13, Ohio.

——Ritin' and Rewards

We can't take *all* the credit for his fame of course, but a MACHINE DESIGN author, Federico Strasser, recently received the Presteel Award. Every year this award, jointly sponsored by the Pressed Metal Institute and Worcester Pressed Steel Co., Worcester, Mass., is presented to someone who makes a "substantial contribution to enlarging the field of metal stampings." Mr. Strasser's article, "Electrical Wire Terminals," in this issue (Page 170) is one of several hundred he has had published in ten languages, in 16 countries, and in 77 trade journals.

——The Last Word on Writing

One of the world's great men of letters, Samuel Johnson, pronounced these words concerning the art, or task if you will, of writing:

1. *Read over your compositions and wherever you meet with a passage which you think is particularly fine, strike it out.*
2. *No man but a blockhead ever wrote except for money.*

As far as these pages are concerned: 1. The editors will take care of your "particularly fine" passages. 2. None of our authors are blockheads.

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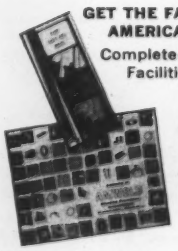

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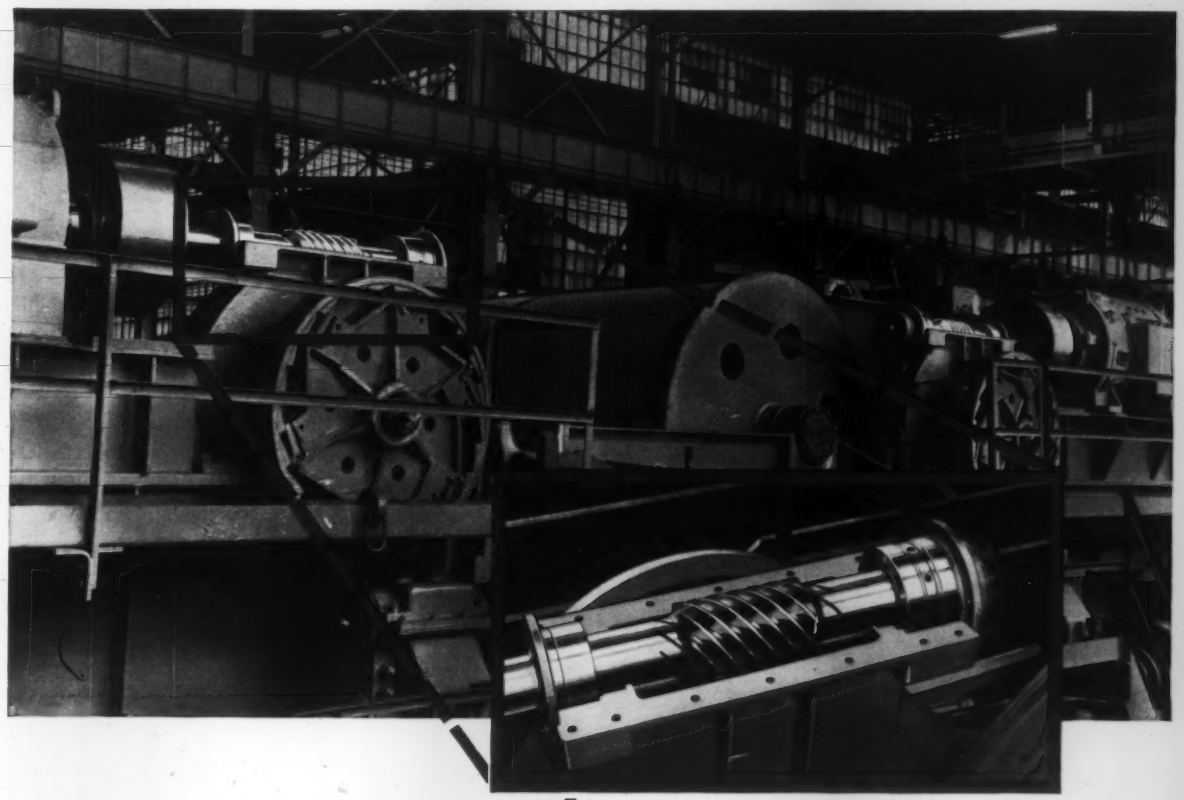

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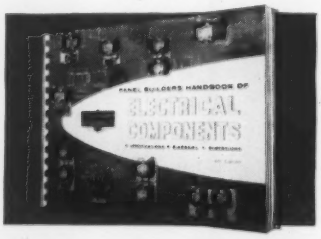

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